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Vol. XXXV, No. 2 *Whole No. 301*

February, 1935

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Origin of the Solar System

The Last Word in Telephotography

Mathematics and Engineering Education

Radio Reception and the Sun-Spot Cycle

A Modern View of the Science of Chemistry

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.
Publication Office: 450 AHNAIP ST., MENASHA, WISCONSIN

Business Manager: 450 Ahnaip St., Menasha, Wis., and 3319 North Fourteenth St., Milwaukee, Wis.

Editorial Office: 7633 CALUMET AVENUE, CHICAGO, ILLINOIS

Published Monthly, October to June, Inclusive, at Menasha, Wisconsin. Price $2.50 per year: 35 cents per copy. Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879.

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Nature never proclaims her secrets aloud, but always whispers them.—John Owen

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School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Published Monthly except July, August and September
at 450 Ahnaip St., Menasha, Wis.

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GLEN W. WARNER
Editor
7633 Calumet Ave., Chicago

W. F. ROECKER
Business Manager, 450 Ahnaip St.
Menasha, Wis., or
3319 N. 14th St., Milwaukee

DEPARTMENTAL EDITORS

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PRICE. The subscription price is Two Dollars and Fifty Cents a year; foreign countries $3.00; current single copies 35 cents.

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MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 7633 Calumet Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor.

SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV FEBRUARY, 1935 WHOLE NO. 301

WHO'S WHO IN THIS ISSUE

CHARLES A ELLIS, Professor of Structural Engineering, Purdue University contributes "Mathematics and Engineering Education." Professor Ellis is not only a very successful teacher but a practical engineer internationally known because of important bridges built in this country and in Canada according to his plans. It is sufficient to say that he is the designer of the great bridge across San Francisco Bay now under construction. Mathematics teachers may not agree with all he says but he gives us something worthy of our attention.

JOHN MILLS, Director of Publications, Bell Telephone Laboratories, needs no introduction to our readers. His latest book "Signals and Speech in Electrical Communication," is a worthy successor to "Within the Atom," "Letters of a Radio Engineer to His Son," etc. In this issue he gives us "The Last Word in Telephotography."

ERNEST A WILDMAN, Professor of Chemistry, Earlham College, is recognized as a leader among teachers of college chemistry in the Hoosier state. He knows chemistry and can teach it. He has made frequent contributions to other scientific and educational journals but his "A Modern View of the Science of Chemistry" is his first appearance before this audience.

HARLAN TRUE STETSON of the Institute of Geographical Exploration is another new contributor. His work at Cambridge and as Director of Perkins Observatory, Delaware, Ohio is well known to all astronomers. Radio fans, amateur astronomers, teachers, and scientists will all be interested in his report on "Radio Reception and the Sun-Spot Cycle" which is an abstract of an address delivered before the Fifth Pacific Science Congress.

MABEL SYKES, one of Chicago's most successful teachers of secondary mathematics and a textbook writer, is a charter member of the Central Association of Science and Mathematics Teachers. She has made numerous contributions to this journal and now favors us with "Some Criticisms of Recent Ninth Grade Algebra Texts", an article chuck full of helpful suggestions for teachers and textbook writers of algebra.

CARL F. HANSKE, another live wire from Hoosierdom tells how Indianapolis organized and administers the science work in the junior high schools of that city. Mr. Hanske's special field is chemistry in the senior high school but he can view the entire field of science education without prejudice and work enthusiastically with the junior teachers and pupils.

WILLIAM T. SKILLING, author of "Tours Through the World of Science," hails from State Teachers College, San Diego, way out west where the desert and ocean meet. His chief hobby is writing science so that everyone will read it and want more. His articles in many recent issues have made him and us a host of friends.

$900 CHUNK OF GOLD USED BY POLISH SCIENTISTS ON ATOMIC TESTS

What a nation does with its gold when it is off the gold standard is revealed in the British science journal *Nature*. Part of the gold locked, by decree, within a country is used for scientific research.

Such is the case in Poland, which forbids shipments of gold from within its boundaries. In Warsaw a group of investigators headed by M. Danysz of the Radiological Laboratory have just completed atomic experiments involving a block of gold valued, in American dollars, at about $900.

The investigation, using the nugget loaned by the Bank of Poland, was to determine what difference a gold filter process would have on the penetrating power of the neutrons. Neutrons are fundamental particles of which all atoms are made.

Danysz and his colleagues find that in silver and iodine much more artificial radioactivity is produced by neutrons when they are first filtered by passing them through the gold block than without the filtering process. For light elements like aluminum and silicon the reverse was true.

The Polish scientists suggest as an explanation, that the neutrons entering the gold strike atoms there, are stopped, and in stopping create other neutrons of slightly less energy. Such slow neutrons are efficient in producing artificial radioactivity in heavy elements like silver and iodine but are inefficient in doing the same thing on the light elements.

MATHEMATICS AND ENGINEERING EDUCATION

By Charles A. Ellis
Professor of Structural Engineering
Purdue University, Lafayette, Indiana

Engineering is one of the oldest of arts, and one of the youngest of sciences. The first artisans were not specialists, but just plain engineers. There came a time, however, when it was desirable to distinguish between the engineer who served with the armies and built their roads and bridges, and those who practised their art in times of peace. The former were characterized as military engineers; the latter came to be known as civil engineers. These two distinctions served for centuries, in fact, until civilization was well into the machine age, when the mechanical and electrical schisms took place.

The first applications of science to the art of engineering were the investigations of building materials, chiefly wood and masonry, which comprised a study of the ways and means whereby these materials resisted stress and strain (aches and pains to you) when they were made to stretch, compress and bend, and to groan inwardly, though silently, under the burdens they were forced to bear as members of a structural body. These studies are known today as structural analysis.

The ancient bridges, the vaults, arches and flying buttresses of the great medieval cathedrals bear witness to structural insight; but the science was born of the art less than 300 years ago. We may say that it began with Galileo, eighteen years after the Pilgrims landed at Plymouth, when he published his structural theory of beams. His theory was incorrect, but it marks the first scientific published thought in this field. It was not until 1776, a convenient date for Americans to remember, that Coulomb, a French military engineer, laid the substantial foundations of structural analysis as we know it today.

The story of this science,* like any other, may be found in the lives of individual men, and as we review its progress since the days of Galileo and Coulomb, a list of many names stands out pre-eminently in this field of intellectual endeavor. To an engineer it is an interesting group of illustrious men. At least nine nationalities are represented. Some were rich, others were

* See "One Hundred Fifty Years Advance in Structural Analysis," *Transactions*, Am. Soc. C. E., Vol. 94 (1930) p. 226, by H. M. Westergaard.

poor. Some had little or no social standing, others were princes of the blood. Some were intensely religious, others were members of the Great Catherine's court. Some demonstrated their theories with all the brilliance of a flash of light in a murky sky, while others were ponderous in thought but no less successful.

Perhaps half of these men are better known today in other fields of intellectual endeavor. Most of us think of Galileo as an astronomer rather than as an engineer. Leonhard Euler was probably the most versatile, certainly quite the most prolific mathematician of all time, yet he gave us the first systematic treatment of elastic curves, and the celebrated Euler formula which expresses the critical load at which a slender column buckles.

Taken, *en bloc*, however, these scientists had two and, to the best of my knowledge, only two points in common. They classify as illustrious engineers and they qualify as mathematicians of much more than ordinary ability.

These many instances of agreement inductively suggest a rather close connection between engineering and mathematics; and it is not difficult to understand why this is so. If I were to make a distinction between engineering and science, I believe it would be this: Science is analytic, engineering is synthetic. The scientist is trying to understand the material things of the world, he is taking them apart and finding out what they really are. The engineer is putting them together and making the world a more comfortable place in which to live. More power to both!

Engineering is based primarily on the physical properties of materials—their weight, strength, stiffness, elasticity, conductivity, etc. The purpose of engineering is design and construction—whether it be a steam engine, bridge, electric generator or an airplane. The method of design is mathematical. Thus physics and mathematics are wed, theoretical mechanics is born and when it grows to manhood it becomes the science of engineering.

We have therefore a community of interest. You represent a large body of teachers,—many of you are teachers of mathematics. If we are not too technical we may say that you are the producers of a commodity known as mathematics. I represent a profession which is a very large, if not the largest, consumer of your product. I know of no profession which requires a wider

knowledge of mathematics than engineering. Do not be alarmed, however, for I am not about to make an impassioned plea for bigger and better mathematics, that is—not exactly.

The value of a product depends upon what use is to be made of that product. To my grandmother the value of a spinning-wheel was measured in terms of its usefulness as a machine for making yarn out of wool. Today the value of that same spinning is measured in terms of its usefulness as a curiosity or as an antique. When we attempt to place a value upon mathematics we consider two points of view: first, its value as a part of a liberal education; and second its value as a tool, or a machine into which we may put all sorts and kinds of physical data at the hopper, collecting the answers at the spout. We have some ideas on mathematics as part of a liberal education, some possibly good, and some probably not so good. But that topic is not for consideration this evening. The topic now on the agenda is "Mathematics for Engineers," or if you please, "An Engineer Looks at Mathematics."

At present, mathematics, when bracketed with engineering, is simply and solely a means to an end and never the end itself. To an engineer mathematics is a very highly respected and valuable tool in the analysis of his problems; it is nevertheless a tool. Mathematics may be the queen of sciences to the mathematician but to the engineer she is but a page serving in the outer court, and in this capacity she knows her duties and performs them well. But the engineer has higher aspirations for her, a much higher place at the table of professional men. What more then does the engineer desire?

I have said that the method of engineering design is mathematical, but here I wish to add that mathematics by no means constitutes the whole of design. My meaning will be clearer if we hastily run through the thought processes that conspire to produce the design of some structure, a bridge if you please.

First, the imagination and judgment are set at work. Will it be a masonry arch, a structural steel cantilever, or a wire cable suspension span? The imagination shows how these varied types will appear on the landscape, and judgment, that faculty born of experience, will take the engineer a long way in deciding which type will best fit the geographical conditions, will best serve the purpose, and be the most economical. Instances will arise where judgment alone cannot fully answer the question of economy and some mathematical analysis is required ere the

final decision is reached. Suppose that the evidence favors a suspension bridge. Judgment is again consulted. What are the foundation conditions? Where shall the piers and cable anchorages be located and what shall be the length of span and sag of the cables? Shall the roadway provide two, three or more lanes of traffic, and what is the weight of traffic to be carried in each lane?

Thus, bit by bit, the physical data are collected, observed and judged. Imagination and judgment winnow the chaff from the wheat and there comes a time when the structure appears on the designing board in a line diagram—a geometrical configuration. Each member of the structure has been given a place with a linear dimension; the loads are indicated in their proper places and all the information necessary for the design is at hand.

The structure as a whole must bear the burden of the load, and it asks each member to do its part. The designing engineer, with the aid of mathematics, determines what that part is, and supplies each member with the amount of steel necessary for the task. Watching the designer at his work, you will observe that sheet after sheet is filled with computations as he analyzes the structure. In making these computations the engineer is guided by the theories relating to structures with which he wrestled when he was a student in college. He is now applying them.

When he was a student these theories were developed from comparatively few fundamental principles. Some of these principles are empirical—that is, they are derived from experiment and observation. For example, Hooke's law—two tons will stretch a rod twice as much as one ton within certain limits. This principle is not entirely correct, but sufficiently so for engineering design, and we make the best of it. Other principles are rational—for example, the principle of static equilibrium: If a body is at rest, it moves neither up nor down, neither to the right nor left, nor does it rotate. That principle is absolutely correct.

These principles—some rational—some empirical, some accurate—some not so accurate, but all fundamental, are brought together and introduced all around, so to speak. They are strangers in this new assembly, they do not seem to mix easily, and the situation is somewhat chaotic until they are organized under the constitution and by-laws of algebra.

These seniors who have had a hand in this organizing were

your pupils in algebra a few years ago and they know an algebraic equation when they see one, whether simple or quadratic, and they can solve it, too. They know how to solve algebraic equations and to that extent I have no hesitancy in saying they know their algebra, but I wish to make four observations:

1. The fundamental principles have almost, if not entirely, lost their identity. It is very difficult for the student to recognize the physical conceptions of the problem, when they masquerade in algebraic expressions.

2. The student solves the equations and since he has never known an algebra or a teacher of algebra to be mistaken, he believes his answers are truth itself, forgetting that although the solution of the equations may be correct, the equations themselves are correct only in so far as all the fundamentals are correct.

3. The student for some reason has great difficulty in organizing the principles, in putting two ideas side by side in his thought and getting a third idea out of the two.

4. He has the greatest difficulty in making a practical application of this new found theory after he has developed it.

Summing up the situation briefly, this is what we find. The student cannot correlate several concrete ideas expressed in words and combine them in algebraic expressions. He can solve algebraic expressions when they have been derived. After he has solved them he cannot apply them.

The best method of meeting this situation, as I see it, consists of never tying any fundamental principles together with a formula if it can be helped. Otherwise the physical conceptions can then be kept in sight and when they are in sight the application of fundamentals can be made directly and with reason. This, sad to relate, cannot always be done.

I venture the suggestion that the situation I have described is not unknown to you who teach algebra. You have exercises and problems. Here is an exercise in quadratic equations: given $x^2+15x=54$; solve for x; and here is the corresponding problem. The plate of a mirror is 18 inches by 12 inches and the frame which surrounds it has a surface equal to the glass. How wide is the frame? Solving for x in the exercise involves only one new principle for your pupil—that of completing the square. I hope for his sake that you insist that he complete the square in every exercise he does, for, to me, it seems entirely unnecessary and even sinful to require or suggest to a student that he

memorize a queer arrangement of letters and signs, when all he needs to remember is a sentence of three words. Complete the square!

May I suggest that you do not tarry over-long with the exercises, limit them to three or four; then give the student problems, many problems. Nobody ever saw a quadratic equation running around loose in real life. Whenever it comes into view it is at the end of a problem. The width of our mirror frame may not be very important to anybody, but the location of the neutral plane of a reinforced-concrete beam is extremely important to the engineer. It requires an exercise of imagination and reason to find the quadratic equation in either problem. If you begin the exercise of these mental faculties in the high school and we continue them in college, between us we may develop a mentality which is not only a store house filled with miscellaneous bits of information, but also a power house which can lend force to knowledge and give it a dynamic quality.

Geometry is as old as the history of man. Along with philosophy it held the attention of Pythagoras, Plato, Aristotle, Euclid and others. I do not know whether Socrates was a geometrician or not, but one of Plato's dialogues with Socrates as the center of a geometrical discussion would be interesting reading, and might reflect considerable light on the proper pedagogical treatment of this subject, so peculiar in the household of mathematics.

Geometry perhaps more than any other mathematical subject has been considered a large contributor to liberal education because it stimulates the processes of reasoning. It is well to point out that geometrical deductions are extremely rigid and thereby lack the necessary elasticity of reasoning ordinarily employed in scientific studies and investigations. Geometrical premises are absolutely fixed, while science is concerned quite as much with the premises as with the reasoning.

Consider, for example, the theory of stresses as applied to a reinforced-concrete beam. This theory is developed from four statements, known as fundamental principles. One of these statements is rational and is as true as an axiom in geometry; while the other three are empirical; i.e., derived from observations. Two of these closely approximate the truth and the other is a long way from the truth, but we must give it a definite value every time we design a beam. There are many factors which enter into the strength of a reinforced-concrete beam.

In order to study the effect of any one of them, the engineer must vary this factor in many beams, keeping all other factors as near constant as possible. He determines by laboratory tests the strength of each beam thus made and compares the variation in strength with the variation in the factor.

The very fact that a physical scientist has control over his specimen and can vary his factors at will makes his task much more simple than that of the economic or political scientist; therefore it is safer for us to rely on the conclusions of the physical scientist than on those of his economic and political brethren. But whether the science be physical, economic or political, the observations will be analyzed and conclusions will be drawn by the inductive methods of agreement, difference, concomitant variations or residues—methods quite unknown to geometric reasoning, as for example, in finding the value of π. Did you know that a bill was once introduced in a state legislature to fix the value of π at 3.0? I understand that the bill never became a law.

Since the processes of thought employed in the proof of a geometrical proposition do not parallel those employed by the physical scientist or the engineer, we must look elsewhere if we are to find the true value of geometry to science, or more particularly to engineering. This value is found in the knowledge of geometrical truths which result from proofs rather than in the proofs themselves. It is to *know* that the square of the hypothenuse equals the sum of the squares of the two sides that is important to the engineer. Pythagoras proved it more than 500 years B.C., no one has doubted it, everybody believes it—so why make the boy wrestle with the proof? Why, for one and only one reason—to give him something to do mentally. And how does his mind react on it? Does it reason and argue with the proposition? I ask you. Just before the class is called, doesn't he hurriedly repeat over and over: *ABC* equals *SOS*, *NRA* equals *PDQ*, and finish the alphabet soup with a *QED*?

It is not the teacher's fault if memory is exercised instead of reason. With a given number of propositions to cover in the time allotted there is no time for students to argue over the proposition.

> Theirs not to reason why,
> Theirs but to memorize or die.

If the teacher had only 50 propositions to cover instead of 150 in the same amount of time, much more attention could be given to real mental exercise. Proofs could be given in full, in part or not at all and the student would have time to attempt to do what had been left undone. He would also have opportunity to apply the knowledge he derives from the proof. For example, after similar triangles and their proportionate sides have been treated, give the student a yard stick, a hammer and two or three stakes and tell him to find the height of the flag pole without climbing it.

I believe that this major operation of cutting 150 propositions to one third that number could be done and no strictly useful knowledge be lost, and I will explain why I believe this to be true. I have been a civil engineer all my life, engaged both professionally and academically. One evening recently I counted 152 propositions in a modern geometry and I found less than a dozen, the mere knowledge of which had ever been useful to me as an engineer.

Yes, your high school students know and can do their mathematics, and in this respect mathematics is a page. If she has aspirations to become a lady-in-waiting, I suggest that she look forward to the time when the student must search for and find his own mathematical equation, which ties together several bits of information in such a way that the equation expresses a new idea that can be applied wherever or whenever needed. Deeper, far deeper, thinking than the act of memorizing is required here and the spark plugs that start and continue this brand of thought are imagination and reason.

Speaking of spark plugs reminds me of the sentence that appeared in a freshman's English theme. "In the breast of each student there smoulders a spark of genius which should be watered by the University until it bursts into flame." The metaphor may be a bit mixed but the idea is sound.

My plea, then, for mathematics is fewer exercises, no formulas, more, many more, problems. While you are feeding the student information try also to exercise his imagination and reason. Less food and more exercise is a slogan as well suited to the class-room as to the gymnasium or athletic field. Some students get physically fat on too much bread and meat, many more get mentally fat and sluggish on too much information; and what Indian clubs and dumb-bells can do for one, imagination and reason can do for the other. I have great respect for

the wisdom of the physical instructor. He stands by, observes and directs, but the student does the exercising. They are called "directors" for good reasons.

In case some of you who teach subjects other than mathematics should feel slighted, I have for you a word of encouragement. It may be true that mathematical subjects offer the best opportunities for defeating the student's persistency to memorize, and to insist that he do some thinking, but mathematics holds no monopoly in this respect. The accomplishment rests not with the subject taught, but with the instructor and his class-room technic.

She was teaching physical geography and was very earnest and conscientious about it. When reviewing each chapter she composed forty-nine questions which covered the entire subject matter in that chapter and told the students to find the answers. She was explaining this method to an old and wise gentleman and suggested that he come to school and observe the excellence and erudition of the class. He accepted. The class was called and she handed him the questions. He looked at them for a moment and then asked the class—"If you were to dig a hole deep down in the ground—miles and miles deep—would you find it warmer down there at the bottom of the hole or at the top?" Jaws dropped and silence reigned until the teacher said—"I don't think you asked the question quite correctly; please let me have the questions." He returned them and the teacher said "Attention please. What is the condition of the interior of the earth?" and with one rythmic explosion the class shouted "The interior of the earth is in a condition of igneous fusion." "You see" said she "you did not ask the question correctly." That story told in a few words illustrates much better than I could possible express, the idea I have been trying to develop.

I try to practise what I have been preaching. Each new principle or theory is discussed in class before the students have had opportunity to learn it from the textbook. First I sketch the history of the origin and development of each theory and tell the class that it was discovered by some mortal man and not handed down from heaven as were the ten commandments. Then by continuous oral quizzing the theory is developed. I try not to do their thinking for them but simply guide their thoughts in the right direction by questions which direct rather than lead.

Oral quizzing is a fine art, and he who practises it should do so with the idea of first getting upon common ground with the student by touching the latter's own personal experience. This enables the student to put side by side in his mind two ideas never before linked together in his thought. By this method I firmly believe the student will develop real mental power to cope with life's problems, the answers to which are not to be found in any mathematical expression or between the covers of any textbook.

MEXICAN MOUNTAIN TOP COSMIC RAY EXPEDITION FINDS NORTH-SOUTH VARIATION EXPLAINED BY EARTH SHADOW

New confirmation that cosmic rays consist, in a large measure, of charged particles streaming down on the earth from outer space was presented before the Franklin Institute by Dr. Thomas H. Johnson, assistant director of the Bartol Research Foundation, Swarthmore, Pa.

Dr. Johnson recently returned from a cosmic ray expedition to Mexico where his party climbed the 14,000 foot peak of Nevado de Toluca, fourth highest mountain in the country.

Using heavy and elaborate apparatus which measures the intensity of cosmic radiation as it varies from zenith down to horizon, Dr. Johnson detected a greater intensity from the south than from northern directions.

These results tie in with his previous discovery that cosmic ray intensity also is greater from the west than the east. Both results are explainable by previously developed cosmic ray theories of Prof. Carl Stoermer, Dr. P. S. Epstein and Abbé Lemaître (inventor of the expanding universe) and Dr. M. S. Vallarta.

To explain the north and south difference of cosmic rays is the concept that the earth casts a magnetic shadow. Says Dr. Johnson, "Due to the magnetic field and to the fact that the rays are electrically charged, the orbits are curved, and, if the earth were transparent to cosmic rays, much of the intensity which would be observed at the earth's surface would be due to rays which had previously been inside the earth. From inside the earth they would be turned back by the magnetic field into the region above the earth where they would again be turned down to the observer.

"Rays traveling such orbits as these are, of course, stopped at their first entry into the earth's surface and their absence on the remainder of their hypothetical path, appears as a complete shadow from the directions below the horizon and as a partial shadow from directions above the horizon," he added.

"The partial shadow is the more dense, according to experiment and theory, from northerly directions than southerly directions in the northern hemisphere."

—*Science Service.*

GENERAL SCIENCE IN INDIANAPOLIS*

By Carl F. Hanske

Emmerich Manual Training High School, Indianapolis, Indiana

THE INDIANAPOLIS JUNIOR HIGH SCHOOL PLAN

The foundations for a thorough revision of the course of study in science instruction were laid when the Indianapolis Junior High School Plan, involving a reorganization of seventh, eighth and ninth grades, was introduced by Milo Stuart, assistant superintendent, in 1931. This plan affects mainly courses of study and teaching procedures, but incorporates many recognized features of the junior high school without disturbing to any great extent the present administrative organization. Approximately three years were spent in developing and gradually introducing the new course first into the 7B and 8B grades, then into 7A and 8A grades, and finally into the ninth year. More than 600 teachers, working in committees, have assisted in this reorganization of the curriculum.

Following the death of Mr. Stuart (1933) the work of reorganization was placed in charge of Virgil Stinebaugh, curriculum director, who had worked with the assistant superintendent from the beginning in developing the junior high school plan.

Because the work of reorganization is still in progress, it will be impossible at this time to present more than an incomplete picture of the finished course in science. The greater part of this paper, therefore, concerns itself principally with an account of the methods, procedures and techniques employed in developing and organizing the units that make up the course of study for the seventh, eighth and ninth grades.

OBJECTIVES

The objectives of the reorganized courses were carefully established. First, a seminar group completed a careful study of professional literature relating to the junior high school.

Next, a committee of five elementary and high school teachers[1] was appointed to develop the new course in science for the seventh, eighth and ninth grades. This committee began its work by formulating objectives, consistent with basic educa-

* Presented before the General Science section of the Central Association of Science and Mathematics Teachers at Indianapolis, November 30, 1934.

[1] Joel Hadley, chairman, Carl F. Hanske, E. B. Hargrave, P. W. Holaday, Mildred Weld.

tional objectives and the functions of the junior high school, as goals towards which instruction and pupil activities might be directed.

Objectives were validated by such criteria as immediate interests and experiences of the pupil, probable social needs, uses in later school work, current practice as reflected by existing objectives in courses of study and textbooks, and the opinions of eminent authorities.

Objectives established for the course are given below. The purpose of the course is to help the pupil:

1. To take pride in his own physical attainment.
2. To secure a scientific background for proper health habits.
3. To acquire an enriched content of scientific experiences which satisfy practical immediate needs of home and community, leisure time pursuits, and vocational interests.
4. To cultivate a feeling of admiration for all natural beauty and a feeling of reverence for the vastness of time and space.
5. To find a permanent interest in the laws which govern our environment.
6. To attain the powers of observation, habits of inquiry and accurate evaluation of evidence, open mindedness and fidelity to truth.

SCOPE OF SUBJECT AND UNITS

The objectives of the course having been established, the committee made a survey of the general field of science to determine the scope of the subject and formulate major divisions under which all subject-matter might be included. Five all-inclusive headings were found to be adequate, namely,

I. *Physical Environment*, under which were included such topics as air, water, fire, sound, heat, and light.

II. *Living Things* under which were placed such topics as growing plants, gardens, reproduction, useful plants and animals

III. *Health*, and such topics as body structure, nutrition, digestion, germs, stimulants and narcotics

IV. *Industry*, and subject matter relating to machines, work and energy, magnets and electricity

V. *The Universe*,—solar system, constellations

Topics included under these major headings were next assigned to different members of the committee to be organized logically into subject-matter units. Although the various units were produced independently, an effort was made to assure

unity within the several departments. To provide for the best possible relationships and to guard against unnecessary repetition or overlapping, conferences were held at regular intervals with groups engaged in developing units in physical education, home economics, social studies and other related subjects. Such provision was necessary especially in connection with the study of health where certain topics were presented in each of the above courses.

FORM USED IN UNIT CONSTRUCTION

A uniform course of study outline was followed in developing subject-matter units. First, a *Unit Aim* was selected to indicate the relationship between the unit and the science objectives, viz.:

"To give the pupil a comprehension of the balance maintained by nature between the plant world and the animal world and a sense of the constant struggle for survival." (Unit I: 8th grade, Fall Semester—Interdependence of Living Things.)

Next, the materials of the unit were organized under two main headings; namely, *Specific Outcomes* and *Suggested Materials and Activities*. Suggested teaching procedures were based upon either scientific investigations or successful experience. Specific outcomes were stated as information and concepts, habits and skills, and attitudes and appreciations to be acquired by the pupil, viz.:

1. A conviction that life comes only from life.
2. A knowledge that plants and animals render each other a mutual service, such as the exchange of oxygen for carbon dioxide; the exchange of food for the work of pollinization; and of shelter for the service of enemy extermination.
3. An appreciation that man can by his interference upset nature's balance in controlling plant and animal life.
4. Etc.

Suggested materials and activities were stated as desirable pupil activities and teaching procedures which could be planned to bring about the realization of the specific outcomes, viz.:

1. Investigate the traditional story of the horse hair snake, and experiment to dispel superstition, in case the story is still believed by a considerable number of the class.
2. Recall the interdependence of plant and animal life in the case of the apple tree during the flowering season. Enumerate as many instances as possible of the service each renders the

other. Read Chapter I of "New Biology" by Smallwood, Reveley and Bailey.

3. Etc.

Finally, for each unit, a list of available source material, which might be used by teachers and pupils was made. This list consisted of reference books to be found in the city libraries, exhibits, charts, slides, films and illustrative materials to be found in the Children's Museum and Visual Education Department of the city schools, etc.

PSYCHOLOGICAL ORGANIZATION OF MATERIALS

(Grade placement and time allotments)

After the subject matter units had been logically developed, the next task of the committee was to organize the materials of instruction psychologically into teaching units according to the natural interests and experiences of the pupils. Tentative grade placement of the materials was determined largely on the basis of scientific studies concerning relative difficulty of materials, and by current practice. Related materials in the various subject-matter units were integrated into the new units of work around central themes or controlling interests, and tentative time allotments for each were suggested by the committee.

TRY-OUT AND DEVELOPMENT

These tentative units were now placed into the hands of experienced classroom teachers who taught the subject-matter under typical classroom situations in order to test carefully the feasibility of the specific outcomes, and to establish more definitely the grade placement and time allotments. These teachers reported back to the committee their reactions, findings and recommendations using as a guide a questionnaire-form to answer certain specific statements of which the following are illustrative:

1. Reword unit aim so statement will connect unit more closely with subject objectives and reflect more clearly the theme or central purpose of unit.

2. List outcomes not within realm of experience and training of pupils.

3. List outcomes which cannot be mastered by large per cent of pupils.

4. Supplement, eliminate or reword outcomes.

5. List activities which represent common program for all

pupils, those which present a distinct challenge to the bright, and those suited for pupils of lower levels of ability.

6. List activities which do not appeal to the interest of majority.

7. Substitute other activities which afford greater possibilities for bringing about realization of specific outcomes.

8. Examine available source material and suggest best material for particular units. List additional references, etc.

At successive stages in the development of the curriculum, the opinions and advice of eminent educational authorities, from Columbia, Harvard, Chicago, Michigan and leading Indiana universities were sought so that the local program might be mapped out in terms of the general trends throughout the country.

Upon the basis of the results obtained by means of the questionnaire, conferences at regular intervals with teachers actually engaged in using the materials outlined, and the advice of eminent authorities, the units were thoroughly revised by the committee.

CORRELATION

After the course of study had been rather fully developed, representatives of the various committees were organized to work out definite plans for the correlation of the materials in the different subjects in each grade level. Tentative courses of study were carefully checked to discover areas in which two or more committess were concerned with the same materials; responsibilities of various committees in dealing with common materials were clearly defined in order to avoid needless repetition and overlapping in the curriculum; definite suggestions were offered to various committees concerning opportunities for a greater degree of correlation, etc.

When the science-committee representative had checked the units in other courses with science units to locate areas for correlation, meetings with sub-committees of other departments were arranged where such matters as sequence and overlapping of materials, suggestions for repetition or emphasis and cross-reference, were noted and adjustments made. At this time, too, all courses of study were thoroughly examined to insure that the character and citizenship aspects of the curriculum had been definitely included and properly emphasized.

Opportunities for the correlation of science materials with the subject matter of other units were found to exist especially

in courses developed by committees of the physical education, home economics, social studies and shop departments. Materials common to two or more courses of study, namely, food, clothing, diseases, water supply, air, communication and travel and electricity, were especially in need of treatment.

THE COURSE OF STUDY

While a great deal of work has been done in developing, testing and revising the course of study, the work of reorganization has by no means been completed, and the course must still be considered tentative in nature. It is impossible within the limits of this paper to give more than a brief picture of the course as it stands at present. In the following outline, however, the descriptive unit-headings suggest to some extent the nature of the work, and the sequence of subject-matter, the grade-placement of materials and time-allotments are indicated.

SEVENTH YEAR—FALL SEMESTER

Unit 1.	Our Environment—An Introduction to Science	2 weeks
Unit 2.	Harvest Time in the Open Spaces	8 weeks
Unit 3.	The Air Around Us and its Uses to Man	2 weeks
Unit 4.	Water and its Relation to the Changing Surface of the Earth	6 weeks

SEVENTH YEAR—SPRING SEMESTER

Unit 1.	The Human Body	7 weeks
Unit 2.	Clothing	3 weeks
Unit 3.	Fire as the Servant of Man	3 weeks
Unit 4.	Life in the Spring	5 weeks

EIGHTH YEAR—FALL SEMESTER

Unit 1.	Interdependence of Living Things	3 weeks
Unit 2.	Neighbors of the World	5 weeks
Unit 3.	Surface of the World	5 weeks
Unit 4.	Weather and Climate	5 weeks

EIGHTH YEAR—SPRING SEMESTER

Unit 1.	Junior Mechanics: Energy, Machines and Work	5 weeks
Unit 2.	Junior Mechanics: Electricity and Magnetism	5 weeks
Unit 3.	Homes	8 weeks

NINTH YEAR—FALL SEMESTER

Unit 1.	The Scientist and His Problems	2 weeks
Unit 2.	Germs and Diseases	6 weeks
Unit 3.	Light in the Service of Man	5 weeks
Unit 4.	Machines and the Work of the World	5 weeks

NINTH YEAR—SPRING SEMESTER

Unit 1.	Electricity and Magnetism	3 weeks
Unit 2.	Communication	5 weeks
Unit 3.	Transportation	4 weeks
Unit 4.	The Improvement of Life	6 weeks

So far as practicable, the course has been planned on a seasonal basis. The first ten weeks of the seventh-grade fall semester course and the last five weeks of the spring-semester course are devoted to the study of plant and animal life. The same general plan is followed in the eighth grade course, the unit on Homes permitting the introduction of materials relating to gardens, shrubs, trees, lawns, and flowers. Units which may be taught as well at one time as another are left for the winter months. Furthermore, subject-matter that can best be taught in the high schools, where apparatus and equipment are available, and where the training of the teaching personnel is more specialized, are left for the ninth year, although certain subjects may be given an introduction in the earlier grades.

Science is required of all of the 11,000 (approx.) pupils in the seventh and eighth years. Boys and girls are segregated in science and physical education, and the subjects are offered on alternate days to the segregated groups. Class periods are 55 minutes in length, and classes range in size from twenty-five to forty-five.

No textbook has been adopted for use in seventh and eighth grades although the committee spent considerable time in examining and evaluating the numerous and excellent textbooks and reference books on the market. Instead of using a single text, each science room has been equipped with several sets of standard texts for the use of which a small rental fee is charged. Each pupil is also supplied with a standard work-book in which the various units have been rearranged and rebound by the publishing company to fit the particular sequence of the units in our course of study. Many teachers have supplemented the subject-matter in textbooks and workbooks with mimeographed materials of their own.

Four of the high schools in the city offer general science as an elective in the ninth year, with 400 pupils enrolled. In the high school general science is taught five periods a week, in rooms adequately equipped for science teaching, by teachers selected from the general high school faculty. *Problems in General Science* by Hunter and Whitman is used as a text in these classes.

While the course of study outlined was being developed, a course in science for the primary grades has slowly been taking shape. Committees working on this program have kept in close touch with the junior high school committee as development progressed, and both committees have cooperated to affect a close articulation between the two courses. The final arrangement of elements of learning in this course will be such that the work of each grade will rest upon foundations laid in preceding grades; the entire program will be integrated with the science of the seventh, eighth and ninth years, and, so far as possible, with the special sciences of the high school. Growth in science, therefore, should prove a gradual and continuous process as pupils learn to adjust themselves to the elements of their environment while progressing from the primary grades through the junior high school, and finally into the more specialized sciences of the high school.

DUMMY DRY CELLS—DEVICE FOR SAVING BATTERIES IN THE ELECTRICAL LABORATORY

By G. H. Mouw
Chicago Christian High School, Chicago, Illinois

Several devices have been offered to teachers of H.S. Physics to help them save their dry cells from quick ruin in the hands of their students. Unfortunately, most of said devices are expensive and bothersome, and interfere with the full use of the battery. Hence this report on an original method that the author has found completely satisfactory during a couple of years use.

A number of empty (Campbell's) soup cans were secured, the tops neatly cut out, and cleaned. Two Fahnstock single connectors were soldered, opposite each other, to the inside of each can so that the spring clips extended above the top of the can. The cans were then filled to about one-half inch of the tops with dry sand, and melted sealing wax poured in to fill. (A cheap grade of sealing wax, such as used on radio "B" batteries, may be used.) When the sealing wax was nearly hard, a minus sign (−) was impressed near one connector, and a plus sign (+) near the other, with a screw driver.

In the laboratory, a student is assigned an experiment and told to make up his circuit using the "dummy" cells. When ready, he notifies the instructor, who, finding the wiring correct, supplies the student with the regular dry cells, which are then merely substituted for the "dummies."

That some of the less adept fail to make the substitution, and subsequently report excellent results with the dummies, is, of course, no fault of the latter, and furnishes a sort of wholesome inspiration to the rest of the class. In addition to saving of batteries, the instructor will notice other advantages, such as the practical impossibility of burning out instruments by incorrect wiring, and the effective check on careless work imposed by the absolute necessity of consulting the instructor before going ahead.

A MODERN VIEW OF THE SCIENCE OF CHEMISTRY*

By E. A. Wildman
Earlham College, Richmond, Indiana

During the past two decades, particularly, there has been a remarkable increase in knowledge of the structure of matter. This information has been largely the fruition of two experimental discoveries of the last century; namely, the discharge of electricity through gases at low pressures, and the discovery of radioactivity, and of a theoretical development, the theories of quantum mechanics. In consequence we no longer think of atoms as the uncuttable physical units of Dalton and Dumas. They have been shown to contain the familiar negative electrons or negatrons, protons, alpha-particles, neutrons of mass about 1, and positrons. One kind of atoms, those of deuterium, contain deutons, units that may probably be found to occur in other kinds of atoms also. In addition, theoretical considerations seem to suggest the existence of negative protons, neutrons of mass 2, and neutrinos. The chemistry and physics of the atom have thus been enriched to an extent that can as yet not even be predicted. Every few days bring some additional new discovery that serves to illuminate our understanding of chemical properties and reactions. Future chemists and physicists will, no doubt, characterize the nineteenth century as the period of the discovery of thousands of kinds of matter and the twentieth century as the period in which the physical reasons for the existence of the various kinds were made subject to comprehension.

Although the latter process is incomplete and is now undergoing very rapid development it has gone sufficiently far so that one may see readily that the interpretations of chemical changes and properties, that is, the theoretical structure of the science, which have served well until the present time are, in many instances, seriously in need of reconstruction. In order to appreciate the need for such changes one may well discipline himself by examining his chemical conceptions from the standpoint of separating fact and theory. He may, perhaps, find that some of his facts are in reality in the other category; for example, the existence of molecules of strong electrolytes, the idea that

* Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, Nov. 30, 1934.

all metals are elements, his conception of acids and bases, the mechanism of hydrolysis, etc.

In this discussion I propose to outline the theoretical picture of the subject that seems to be implied by our present knowledge and that may well be presented to elementary chemistry students. The contrast with the picture that was given to us during the early part of this century will be obvious.

ISOTOPIC ATOMS

It has been known for over a decade that most of the chemical elements are mixtures of physically different atoms called isotopes. The most obvious property that varies in the case of the atoms of any one isotopic element is the mass. Since the several masses are always very nearly whole numbers, relative to the value 16 for the oxygen isotope O^{16}, it seemed reasonable to explain the difference between the isotopes of an element as being due to a variation of the number of proton-electron pairs in their respective nuclei. However, since the discovery of neutrons and positrons as nuclear constituents it has become apparent that the true explanation may be quite different. Protons have now lost their unique importance as positive units and also as the principal carriers of mass. The difference between isotopes may be due simply to a variation in the number of neutrons. In fact, we do not have experimental evidence that atomic nuclei, other than those of the radioactive atoms, contain electrons, although we have been assuming that they do for several years. At present probably the best way to account for isotopes is to state that their nuclei contain different numbers of mass units and to commit ourselves no further.

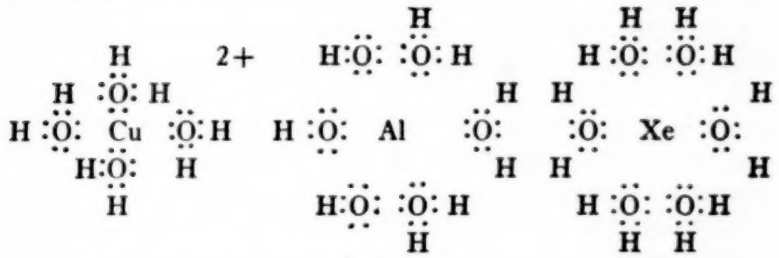
THE NUCLEUS AND CHEMICAL PROPERTIES

The identity of chemical properties of the isotopes of an element is subject to some question because of experiments that have been made on the physiological effect of heavy water. It is to be expected that the nuclei of atoms should have a more profound influence upon their chemical properties than merely that of their periodic variation with atomic number. The periodic law takes no account of the difference between two elements in the same group but in different periods, such as nitrogen and bismuth, or copper and silver. Such differences occur even in the rare gas group. Helium, neon, argon, krypton, and xenon have the chemical property of forming hydrates but

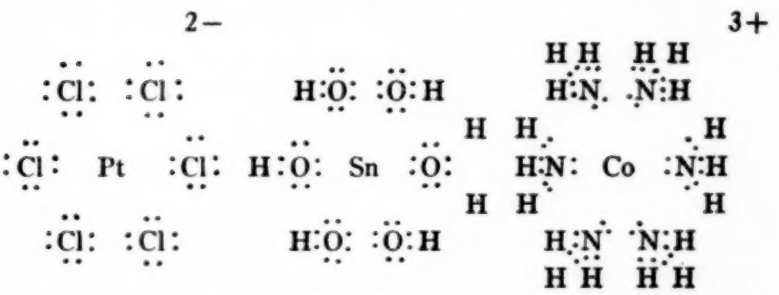
that of the latter is much the more stable. The formation of hydrates by chlorine and bromine molecules appears to be another illustration of nuclear influence on chemical properties, for here, as in the rare gas hydrates, no use is made of the valence electrons of these atoms. We may expect that a great deal more information regarding this subject will become available as the problem of nuclear structure is solved.

THE ELECTRONIC STRUCTURES OF ATOMS AND VALENCE

In spite of the qualifications just made the discovery of the extra-nuclear electronic structures of atoms is one of the great accomplishments of physical science. These structures serve to enlarge greatly the already recognized usefulness of the periodic



Cupric ion hydrate | Aluminum hydroxide | Xenon hydrate



Chloroplatinate ion | Stannic acid | Hexammino cobaltic ion

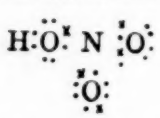
table, for they provide a concrete and physical basis for explaining the several kinds of valence. The nature of electrovalence and covalence, the two main kinds of valence, is being extensively taught in colleges at present and should be an essential part of all chemistry courses.

There appear to be four other types of valence that probably

should be confined to college presentation. Coordinate covalence is a type that explains the existence of the hydrates, ammoniates, complex ions, etc. These are formed because an atom or a cation that has a stable electronic structure according to the ordinary valence rules deduced from the periodic table acquires an additional shell of electrons by sharing several (usually eight or twelve) that belong to some suitable molecule or anion. Examples of these written with Lewis electronic formulas are given above.

Resonance (or oscillation) valence is a kind that seems to account for the bonding of hydrogen in the oxonium ion, H_3^+O, the ammonium ion, the crystalline acid fluorides, and in certain oxygen compounds such as potassium dihydrogen phosphate. In the first and most common instance, the oxonium ion, it is supposed that each one of the three hydrogen atoms may change in rapid succession from attachment to the oxygen by a covalent bond to attachment by an ionic or electrovalent bond. On account of this oscillation the ion is symmetrical, all three hydrogen atoms being in effect attached in the same manner. The phenomenon is similar in the other instances mentioned.

Semi-ionic valence[1] is the type that has been improperly called "semi-polar" valence.[2] It occurs most commonly in such compounds as sulfur dioxide, sulfuric acid, nitric acid, etc., in the attachment of some of the bivalent oxygen atoms to other atoms. For example, in the structural formula of nitric acid:



the electrons indicated by "x" are those contributed by the nitrogen atom. The oxygen atom represented below the nitrogen atom is attached to the latter by one normal covalence and one electrovalence. In other words, the nitrogen and the oxygen atoms are monovalent ions, the first positive and the second negative, but they are attached to each other by a covalence. In consequence, the bonding force between this oxygen atom and the nitrogen may be said to be semi-ionic.

Polar covalence[3] is a kind that has been improperly called

[1] Noyes, W. A., "The Electron Structure of Inorganic Complexes," *Journal of the American Chemical Society*, 55, 4889–93, December, 1933.

[2] Wildman, E. A., "The Need of Modernizing the General Course," *Journal of Classical Education*, 12, 11–16, January, 1935.

[3] Wildman, E. A., loc. cit.

"partial polarity." It is a covalence in a polar molecule, that, is, one in which there is an unsymmetrical distribution of the electrons with respect to two or more atomic nuclei. Such molecules are said to have an electric moment or a dipole moment. This is a physical property of molecules that may be determined experimentally in several ways. Hydrogen molecules and chlorine molecules, for example, have practically no electric moment (they may have a little if there is sufficient thermal agitation to distort them). Hydrogen chloride molecules, however, have a definite and permanent moment. Therefore we conclude that the two atoms in the latter are bound together by a polar covalence and we represent the fact in an electronic formula by placing the dots that represent the shared pair of electrons nearer to the Cl than to the H, as $H:\dot{\underset{\cdot\cdot}{Cl}}:$. This situation obtains, of course, in the majority of covalent compounds.

OXIDATION AND REDUCTION

For a number of years oxidation and reduction have been interpreted as phenomena that are accompanied by a loss or a gain, respectively, of electrons by the atoms or ions that are involved, or by changes in positive and negative valences, which amounts to the same thing but with different terminology. The scheme worked so well when the changes were from atom to ion and the reverse that it was extended to non-ionic or covalent changes as well by assuming a kind of pseudo-ionic character for the atoms. For example, manganese in the permanganates is regarded as having a valence of +7 because of having lost seven electrons per atom. When the permanganate ion is reduced in acid solution we say that the manganese atom regains five electrons.

Such an interpretation has recently been justified by having been given an experimental basis due to the discovery of semipolar bonds and particularly of polar covalence, the existence of both of which is indicated by dipole moments. It is both possible, therefore, and desirable at the present time to attribute to the oxidation-reduction reaction the importance and the wide scope that it deserves. It is the one and only type of chemical change. Direct union, decomposition, displacement, substitution, addition, neutralization, electrolysis, the dissolving of ionic compounds, and crystallization may all be classed as kinds of oxidation-reduction reactions. There is not sufficient

time to discuss this topic here. We may simply illustrate the use of the polar covalence conception in explaining the oxidation of hydrogen and the reduction of chlorine when the two elements unite to form hydrogen chloride, a direct union reaction:

$$H\!:\!H + :\!\ddot{\underset{\cdot\cdot}{Cl}}\!:\!\ddot{\underset{\cdot\cdot}{Cl}}\!: \rightarrow 2\ H\!:\!\ddot{\underset{\cdot\cdot}{Cl}}\!:$$

The formulas are constructed so as to indicate the "loss" of electrons by hydrogen atoms and the "gain" of them by chlorine atoms.

STRONG ELECTROLYTES AND IONIC EQUILIBRIA

After somewhat more than two decades of growth the theory of complete ionization of strong electrolytes seems to be upon a substantial basis. It is a theory that is concerned primarily with the state of such compounds when they are dissolved in a polar solvent such as water. According to it the ions of such compounds are not united with each other as molecules to any appreciable extent or at any time during the existence of a solution. They dissolve from the crystal individually and remain separate from each other until crystallization occurs. The fact that conductivity, freezing point, vapor pressure, and osmotic pressure measurements do not indicate the expected activity of the ions is accounted for by their having decreased mobility because of their electrostatic attraction for each other and for solvent molecules, of friction within the solution, and of Brownian movements, etc. It has not been possible to prove that there are no molecules in solution, but the burden of proof is on the other side, that is, there has never been proof that they are present. They were assumed by Arrhenius.

It happens that most of the reactions of strong electrolytes occur in water solution and we are, therefore, particularly concerned with their nature while in this condition. It should be mentioned, however, that X-ray crystal analysis has strengthened the case for complete ionization by revealing the fact that many of the strong electrolytes are ionic in their crystals. This fact does not necessarily apply to all compounds that may produce strong electrolytes in solution, however, for in solution the ions are hydrated, whereas, in the crystal they may or may not be. Anhydrous aluminum chloride, for example, is a covalent compound. It may react with water and form a crystalline hydrate, an entirely different compound that is a strong electrolyte.

In the past we have been conditioned into thinking of ionization as a *process* that occurs when an electrolyte is dissolved. The present view is that we are dealing with a *state* or *condition* of those compounds that are strong electrolytes. Probably we should restrict the use of the term to the process, that is, to the formation of ions when weak electrolytes are dissolved. It is obviously incorrect to write equations that purport to represent the ionization of strong electrolytes, that represent ions in equilibrium with molecules that do not exist. And it is equally incorrect from the reaction mechanism standpoint to write equations that contain molecular formulas for strong electrolytes. These remarks refer to most of the reactions that are used in qualitative analysis. Students who learn to write molecular equations in their beginning study of chemistry are greatly handicapped in writing ionic equations. Only the better ones and those who discipline themselves especially rigorously are able to overcome such misguidance.

ACIDS, BASES, SALTS

In the last ten years the theory of acids and bases has undergone very extensive revision. Let us approach the subject by recalling briefly the evolution of acid-base theory since Lavoisier. An acid has been (1) an oxide of a non-metallic element (1787), (2) a hydrate of such an oxide (around 1800), (3) a compound derived from such an oxide and containing "water of composition" (Davy, 1810; Graham, 1833; Liebig, 1838), (4) a compound that contained replaceable hydrogen as its essential constituent (Davy, 1815; generally accepted about 1850), (5) a compound that dissociates hydrogen ions when in water solution (since the Arrhenius ionization theory about 1887). The conceptions of bases run parallel with those of acids, from Lavoisier's idea that they were oxides of metals to the more recent view that they were compounds that formed hydroxyl ions in water solution. Throughout this time a salt was regarded as the chief product of the neutralization reaction between an acid and a base, water also being obtained in most instances but more or less incidentally.

The conception of acids and bases that was introduced by the Arrhenius theory of ionization persisted for about one-third of a century until it was revised in 1923 by Brönsted, particularly. The older theory had failed to account satisfactorily for the general behavior of acids and bases in non-aqueous solvents

and especially for acid and base catalysis in such solvents, it having been found that the speed of a catalyzed reaction bore no relation to the concentration of hydrogen ions.

The new theory is simple, but it has a surprising number of implications. It defines an acid as a substance that dissociates protons (hydrogen ions) and a base as a substance that combines with protons. In consequence, the dissociation of an acid produces a base in addition to the proton:

$$\text{Acid} \rightleftarrows \text{Proton} + \text{Base}.$$

This means that all negative ions are bases in greater or smaller degree. Sodium hydroxide, which we have heretofore regarded as a base, is instead a salt. The hydroxyl ion alone is the base in this compound and it is only one of the many hundreds of bases that are known, even though it is probably the most common one.

The proton that is dissociated by an acid is practically unknown in the free or "bare" condition. It attaches itself to something—either to some basic ion or to a solvent molecule. In the latter case the solvent acts as a base. In water solutions all acids form one unique substance, the oxonium ion, $H_3{}^+O$, which is produced by the reaction of the acid (H-Base) with water molecules:

$$\text{H-Base} + H_2O \rightleftarrows H_3{}^+O + \text{Base}^-.$$

Oxonium ion is, of course, an acid by definition. Water acts as a base in this reaction. Water may act as an acid also, for example, when it comes into contact with a very strong base such as oxide ion:

$$H_2O + O^{2-} \rightarrow 2OH^-.$$

One may be inclined to ask what reason exists for adopting a theory so radically different from the one we have been accustomed to? It is adequate to answer that it seems to be nearer the truth than the older theory, for it accounts satisfactorily for the reactions in non-aqueous solvents as well as for those in water. No amount of inconvenience is too great for a scientist if thereby he may acquire a greater knowledge of truth.

According to the new theory the terms "strong" and "weak" do not mean large and small degree of ionization, but large and small ability to dissociate protons in the case of acids, and to associate with protons in the case of bases. All electrolytes are classed as salts. This includes all of the hydroxides and also

the oxonium compounds that are found most commonly as water solutions of acids, although many of them are known in the crystalline form also. All cations may act as acids and all anions as bases. Some cations may act as bases also and we call them amphoteric. Some anions may act as acids. The terms "acid salt" and "basic salt" are inaccurate, for either ion of a salt may be an acid and the compounds that have been called basic salts are hydroxy-salts in which the other anion besides hydroxyl is a base as well.

The terms "basic oxide" and "basic anhydride" are misnomers. They have referred to most of the oxides of the electropositive elements but these are salts that contain the strong base, oxide ion. There is less objection to the terms "acidic oxide" and "acid anhydride." They are class names for covalent compounds, not salts, that react with some hydrogen containing compound and form an acid. But we need a more general term that is not limited to an oxygen or a water system. Included within this class of reactions are such as the following: (1) the reaction of carbon dioxide with water to form carbonic acid, (2) that of carbon disulfide with hydrogen sulfide to form thiocarbonic acid, and similar reactions of selenides and tellurides, (3) reactions similar to that of gold chloride with hydrogen chloride to form chlorauric acid, and of boron trifluoride with hydrogen fluoride to form hydrofluoboric acid.

There is an old elementary chemistry experiment in which zinc is treated with a dry solution of hydrogen chloride in toluene. Because we saw no hydrogen given off we said that hydrogen chloride was not an acid under such circumstances. Zinc would react only with hydrogen ions and water was necessary to cause ionization of the hydrogen chloride. If a student by chance happened to see a bubble of hydrogen we told him that his test tube must have been moist—so blinded were we by mistaking a theory for a fact. The real fact is that at least one metal, aluminum, reacts readily with anhydrous hydrogen chloride and gives hydrogen. Some of the other metals that do not react obviously, probably do so sufficiently to form an insoluble protective coating.

We see now that salt formation is incidental in neutralization. In fact salts may be prepared from anhydrous oxides by fusion methods without neutralization occurring. The latter is a general term for the lowering of proton mobility to the level characteristic of the solvent in which the reaction occurs. In water

it is commonly a reaction of oxonium and hydroxyl ions:

$$H_3O^+ + OH^- \rightleftarrows 2H_2O.$$

HYDROLYSIS

Formerly we thought that hydrolysis was caused by the unequal reaction of the ions of water with those of a salt. It was a far-fetched theory in view of the extremely small amount of ionization of water, about one molecule in a half-billion. We may now explain hydrolysis as a reaction of water *molecules*, a reaction that is dependent upon their property of dissociating protons on the one hand or of associating them on the other, in other words upon their property of being amphiprotic. We formerly said also that the acid or alkaline reaction of a normal salt was *due to* or *caused by* hydrolysis. According to the new theory the acid of alkaline reaction of a salt solution is due to the unequal degree of the acid and basic properties of its own ions. In consequence of this they react unequally with the amphiprotic water and form either some oxonium ions or some hydroxyl ions. For example, the slightly acid ammonium chloride is so because the ammonium ion is an acid, a weak one, to be sure, but a stronger acid than chloride ion is a base. Water is a stronger base than chloride ion so the reaction:

$$NH_4^+ + H_2O \rightleftarrows NH_3 + H_3O^+,$$

with water molecules occurs and two acids are present. The two bases, water and ammonia, both escape on boiling.

Sodium carbonate is alkaline because carbonate ion is a fairly strong base and sodium ion a very weak acid. The reaction with water is:

$$CO_3^{2-} + H_2O \rightleftarrows HCO_3^- + OH^-.$$

Sodium bicarbonate is also alkaline in spite of the fact that it has been called an "acid salt"—one of the anomalies of the old theory. Bicarbonate ion reacts with water molecules also:

$$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-.$$

On boiling carbonic acid decomposes and carbon dioxide escapes.

COMPLEX IONS AND "WEAK SALTS"

The new acid-base theory forces us to attach great importance to the much neglected water of hydration of ions. It is because of this fact that we are able to regard metal cations as acids.

Aluminum ion is an example. When its solution is treated with any of a number of bases, such as hydroxyl ion, ammonia, carbonate ion, or sulfide ion, protons are removed from it and the hydroxide is precipitated:

$$Al(H_2O)_6^{3+} + 3NH_3 \rightarrow Al(OH)_3(H_2O)_3 + 3NH_4^+.$$

If the base used is sufficiently strong, such as hydroxyl ion, at least one more proton may be removed from the complex and aluminate ion be formed:

$$Al(OH)_3(H_2O)_3 + OH^- \rightarrow Al(OH)_4(H_2O)_2^- + H_2O.$$

The definition of salts to include all electrolytes leaves the few compounds that have been called "weak salts" in an anomalous position, for in so far as they are not ionic they are not salts. The way out of this difficulty seems to be indicated by the discovery that several of these compounds contain complex ions. A solution of mercuric chloride, for instance, contains a relatively low concentration of mercuric and chloride ions. Upon electrolysis mercury is found to migrate to *both* electrodes, so part of the mercury must be in a complex anion, or several kinds of complex anions, such as, $HgCl_3^-$, $HgCl_4^{2-}$, $Hg_2Cl_5^-$, $Hg_2Cl_6^{2-}$, etc. Crystalline mercuric chloride is shown not to contain chloride ions by the fact that it sublimes unchanged from boiling concentrated sulfuric acid. There is evidence also that ferric thiocyanate, cuprous and cupric halides, cadmium halides, ferric chloride, and lead acetate are not really the salt-like compounds that there names indicate but compounds that contain complex ions.

METALS

For many years the elements have been classified as metals and non-metals. The most important property of the metals from a chemical standpoint has been said to be that of forming cations. This view, of course, implies that metallic properties are atomic properties. There is a considerable body of information, however, that indicates that the physical properties of metals are connected with a close-packed aggregate of atoms rather than with a single isolated atom. Further, it is known that these physical properties are not confined to the elements that form positive ions, or even to elements, for some compounds have them. Such substances are graphitoidal silicon, graphite, galena, iron pyrite, tetramethyl ammonium radical, etc. It has been suggested that metals be defined as substances

that conduct electricity without material transfer, that have high luster, and that possess a close-packed structure. These physical properties seem to be caused by a peculiar condition of the electrons in the metal. These are to a considerable degree in the free state, that is, they are free to move independently of the atomic lattice. It is supposed that these electrons form, perhaps, an interpenetrating lattice of their own. At any rate they act much like a gas that is under very high pressure or at very low temperature. It is concluded, therefore, that the unique and most characteristic properties of metals are due to this peculiar state of the electrons. Wherever it is found a metal exists, regardless of whether the positive ions present are all alike or not.

FACTORY WASTES MADE HARMLESS TO FISH BY NEW TREATMENT

What is believed to be the first adequate method of halting sporadic fish killings in Michigan streams has been perfected and installed by the Chevrolet Motor Company through direct treatment of cyanide-bearing wastes before being discharged from the plant into the Flint river.

The automobile concern has installed the equipment in co-operation with the Michigan State Department of Conservation and the Michigan State Stream Control Commission.

Solutions containing cyanide are used in most metal-cleaning processes, and a number of fish killings have occurred in various parts of the state in the past five years as a result of discharge of this highly toxic waste.

The equipment consists of a rubber-lined steel tank forty feet in length, five feet wide and four feet high. Cyanide-bearing wastes on being received in the treatment tank are first neutralized with acid. The mixture is then aerated and the released gases are collected under a hood. They are finally discharged into the air under forced draft through a sixty-foot stack.

The waste water then may be dumped into the water without harmful effect.

The installation is the result of a co-operative research effort conducted by agencies of the University of Michigan and the Michigan State College.

Dr. Carl L. Hubbs, director of the Institute for Fisheries Research at the University museum, undertook experiments in 1932 to arrive at the strength of cyanide solution that would prove non-toxic to fish. He also found that when such solutions are aerated they become much less toxic to fish.

The engineering experiment station at Michigan State College has published the results of the studies and conclusions of E. F. Eldridge, of the station, pointing to the method of treatment adopted by Chevrolet here, which consists of neutralization and aeration.—SCIENCE SERVICE.

SOME CRITICISMS OF RECENT NINTH GRADE ALGEBRA TEXTS

By Mabel Sykes
Chicago, Illinois

Three articles have recently appeared dealing with the content of ninth grade algebra, two in School Science and Mathematics for October;—"A Suggestive Course of Study for Junior High School Mathematics," by F. L. Wren and Ruth Moncreiff and "Typical Divisions of Ninth Grade Algebra," by Joseph J. Urbancek, and one in *The Mathematics Teacher* for October; —The Changing Content of Ninth Grade Mathematics Texts" by Ruth Olson. A study of recent algebra texts for the ninth grade suggests other interesting developments in the newer books, developments not included in the articles referred to above. The discussion that follows is based upon ten books with the following copyrights: one of 1928, two of 1929, three of 1932, two of 1933, and two of 1934. The books were studied not only with respect to content, but also with respect to order and treatment of topics, provisions for individual differences, modern type objective tests, systematic instruction in problem solving, and diagrams and pictures.

THE PLACING AND TREATMENT OF CERTAIN TOPICS

No count was made of the number of pages devoted to each topic discussed below or of the number of exercises given under each, although such a count for the 1932, '33, and '34 books would be of interest when compared with the results given in the articles referred to above. It is evident, however, that the emphasis placed upon any particular topic depends not only upon the number of pages devoted to that topic but also upon the mode of treatment and the use made of it later. A topic might be given a complete discussion near the end of the course, but the emphasis thus placed on it would be very much less than if it were introduced near the beginning and featured throughout, although the total number of pages devoted to it might be the same in each case.

Graphs. The treatment of graphs is an illustration of what is meant. Two of the books studied postpone statistical graphs until the middle or the end of the year's work. It is, or course, perfectly possible to give a thorough treatment of the subject where these authors have placed it. When, however, it is intro-

duced at or near the beginning, the author can give the entire subject of graphs a very different kind of emphasis than is otherwise possible. He has an opportunity of developing the various phases of the subject in a way that is complete and easily understood by the pupil. If an author wishes to feature graphs throughout the course he can best make graphs of formulae, of equations, and of problems thoroughly understood by the pupil so that he gets both pleasure and profit from the subject, by working up the entire topic from the foundation at the beginning of the course.

Time, rate and distance problems are better understood if introduced by the graphic solution. But the desired end can hardly be obtained by springing the subject of graphs at this time upon a class entirely unprepared for it.

The graphic solution of a pair of simultaneous equations checks the algebraic solution in a way that is a joy to mathematical minds. The agreement between the algebra and the geometry is one of the prettiest things in mathematics. If, however, the pupil is to appreciate this even in a small way, the subject of graphs should be so familiar to him when he comes to simultaneous equations that as little time as possible may be spent upon the technique. Moreover, this work should be placed as an introduction to such equations not as an appendage after the algebraic solution.

One wonders if an author who does not introduce the subject of graphs at the outset as suggested above has not himself missed part of the point and the joy of graphic work.

Formulae. It seems to be generally admitted that the study of formulae is not only a desirable but even a necessary part of ninth grade algebra. In none of the ten books studied are formulae touched upon incidentally but in each book they are introduced as a definite unit at the beginning and are given a place in many subsequent units. After the preliminary work, formulae can and should be introduced with the solution of integral equations, with fractional equations, with fractions, with radicals, with incomplete quadratics, and wherever literal equations of the usual algebraic type are studied. In at least one book such literal equations are called formulae. To make the study of formulae complete and effective their continual study is essential. It should be noted, however, that the formulae introduced at the beginning of the course should include only those which have meaning to the pupil. All others should

be postponed until he has had more practice in the use of letters for numbers.

In this connection the difference between formulae and equations should be noted, in as much as it may be the unrecognized cause of much of the difficulty that pupils have with formulae. In each case the pupil is, of course, using letters in place of numbers, but in the equations studied in the early part of the work each letter stands for some one definite arithmetical number that he is to find. This is not true of the letters in a formula. This difference should be clearly understood by the pupil and plenty of time should be given to the study of formulae and to the methods of dealing with the same. The early work should, as has been said, be confined to formulae that have meaning to the pupil.

Introductory equations. The study of equations may begin before the study of signed numbers, if such study is confined to equations with positive roots, and if the equations are of the simplest kind. This method of introducing equations seems to be used largely in the newer books. After drill on the four typical forms, such as: $x+5=12$, $x-5=9$, $3x=15$ and $x/3=15$, the pupils readily learns to handle equations that are a little harder, such as: $7x-5=4x+10$ or $3x+21=3+5x$. The better pupils will write at once $3x=15 \therefore x=5$ from the first and $18=2x \therefore 9=x$ from the second. It makes the work simpler for pupils if new ideas are introduced separately; the easier first.

Linear systems. Perhaps the most interesting thing in connection with the order of topics is the place allotted to linear systems. There is no question but the solution of systems like:

$$\begin{matrix} x+y=9 \\ 2x-y=6 \end{matrix} \text{ or even } \begin{matrix} 3x+4y=24 \\ 4x+3y=25 \end{matrix}$$

not only involve no great amount of algebraic technique but, moreover, afford a beautiful illustration of the application of addition and subtraction. Why this work should be postponed until after fractions and fractional equations is difficult to see. Whatever may have been the original reason for the orthodox arrangement, this arrangement seems to have persisted down to the present day. (See the article by F. L. Wren and Ruth Moncreiff in SCHOOL SCIENCE AND MATHEMATICS for October.) Teachers are conservative. For this or for some other reason, it seems to be hard to make any change in the place where a subject is introduced or in the method of its presentation that once

gets fastened upon textbooks and school. The much talked of necessity of classes working together because of transfers of pupils from one school to another has certainly been over emphasized. At best it can hardly apply except to schools in the same town or city. As early as 1907 a well known ninth grade algebra text introduced linear systems in the pedagogical place. But the book was ahead of its time; algebra teachers were not ready for it. The ninth grade algebra world is beginning to see the light, however, four of the ten books studied have placed this topic before factoring and fractions. They are certainly to be commended for the courage displayed. Incidentally one wonders why the class should be deprived of the fun and profit obtained by solving a problem by two as well as by one unknown when both methods are possible.

One wonders also if the unity and coherence obtained by solving the various kinds of equations with one unknown only, before studying equations with two unknowns really appeals to ninth graders. The unity and coherence here involved might appeal to a class in intermediate algebra composed of eleventh and twelfth grade pupils, in as much as the work in linear systems is here followed by some types of systems involving quadratics. Such classes are supposed to have had linear systems in the ninth grade. They need the review of the methods there employed for use in the higher systems. But this hardly applies to pupils in the ninth grade where the pedagogical question is entirely different.

PROVISIONS FOR INDIVIDUAL DIFFERENCES

The problem of individual differences is one of the most pressing, if not really the most pressing in ninth grade algebra classes today. Of the various attempts at solution two are in more or less general use, namely: ability grouping and differentiated assignments.

In some places where ability grouping is being tried different books are used for classes of different levels of ability. Books well adapted to the lowest group are scarce, however, and it is partly on this account that efforts to solve the problem by this method are not as successful as many had hoped. A similar difficulty arises if the teacher wishes to make differentiated assignments in teaching a heterogeneous group. In this case only one book can be used and the time necessary to make the proper selection of exercises for each assignment is considerable

of a burden. It is evident, therefore, that in the problem of dealing with a wide range of individual differences by either method, the book difficulty is extremely acute.

Of the ten books studied six make a definite claim of meeting this difficulty. Those that do not, have the following copyrights: one each of the years 1928, '29, '32 and '34. The latter book, however, is evidently planned to sidestep the problem by a peculiar arrangement of topics. This arrangement puts factoring and fractions at the end of the year's work and makes the earlier part of the course easy and as far as possible practical. The first part of the course, which is evidently the work of the first semester and part of the second, consists of work which is most likely to remain with the pupil and which is most likely to be of use later, especially to pupils who do not go to college or even go on with mathematics.

Of the six remaining books four give occasional lists of harder exercises intended for honor or brighter pupils and definitely marked in some way. Some of these lists are given along with the regular class exercises and some at the end of chapters. Two books only have harder exercises that are definitely marked and that are given directly with all class exercises. The teacher who said that it would be "wonderful" to have all sets of exercises divided to meet different levels of ability probably spoke for all teachers who are giving the problem of individual differences serious consideration.

The ideal way would seem to be a division of all sets of exercises into three groups suited to different levels of ability. In this arrangement the lists of the easiest exercises should in every case be long and should contain considerable material fitted for oral class work. When the explanations and the accompanying drill begin to take effect, the better pupils can be allowed to go on with the next harder set of exercises while more drill on the easy work is given to the rest of the class. In this way the assignments gradually become differentiated while the entire class gets, at least, a knowledge of fundamental principles and methods, and an ability to apply them to easy exercises. The better pupils do not need all of this easy drill and would only be bored by it. They really do need some of the harder work. It keeps them working to capacity, gives them a foundation that they will need for further work in mathematics and, as has been said, also serves to keep them suitably humble. The writer has seen no book that fully meets these requirements.

USE OF MODERN TYPE TESTS

Modern type objective tests have found their way into the algebras. Of the books studied one only makes general use of various kinds such as timed tests, selection tests, false-true tests and the like, in connection with the regular daily work and in reviews at the end of the chapters and of the book. Taking the ten books as a whole timed tests seem to be the most popular. One book makes extensive use of them. Many books give occasional exercises modeled after the various kinds of objective tests scattered among exercises of the traditional type.

This occasional use of such exercises may be both interesting and profitable. But the value of continual extensive daily work of this kind may be questioned for two reasons:

First. They do not in any way take the place of the ordinary exercises such as are usually found in algebra texts. These traditional type exercises require a kind of sustained thought and attention that the short answer questions do not. The drill on these longer exercises and the thought and attention required for the solution of each are essential if the pupil is to acquire any thing like algebraic technique.

Second. The purposes to which such tests are usually put are hardly served by placing them in the hands of the pupils in advance, as would be the case if they are in the book in use.

The work of different teachers and of different schools can be compared by the use of objective tests in as much as they are the only kind of tests from which a given paper can and should receive the same mark when scored by different individuals. This is not true of the old type of algebra examination unless each question is marked either right or wrong regardless of the gravity of the error made. Obviously tests used to compare the work of different classes or of different schools should not be given the pupils in advance.

Teachers can, many probably do, test their own classes by using standardized objective tests. Here again it is not customary to give the class the test in advance.

An objective test may be so constructed as to be of considerable value for diagnostic purposes, expecially in certain topics. If the same type of question recurs at stated intervals it is a simple matter to determine where the class as a whole or some particular members of it find difficulty, for example: a test may consist of a series of equations such as, $x-5=12$, $x+7=13$, $3x=21$, $x/2=8$, $x-7=20$, $x+2=15$ and so on. If the set is

fairly long and every fourth equation is of the type $x/2=8$ and if it is generally wrong on the papers submitted, it is evident that the class needs more drill on equations of this kind. It is also possible to tell from such a test whether the mistakes of some particular pupil are due to lack of understanding of the fundamental principles involved or are mere blunders. But here also the teacher does not give the pupil the test in advance.

In general, therefore, one can hardly see why the tests should be placed in the textbook, unless they are to serve as models from which the teacher may, if he likes, construct similar tests for his own class. In this case it seems as if this fact should be stated in the preface.

The value of timed tests is questioned for another reason. The thing of prime importance in algebra is accuracy, not speed. The conscientious, nervous or timid child often finds that the necessity of completing a test in a given time results in blunders and inaccuracies that might not otherwise occur. An instructor must, of course, use his judgement as to the time to be allowed a class to complete any work. There is a limit. But, in general, if habits of accuracy are insisted upon, speed will ultimately take care of itself. A test of five questions on which the child is required to be perfect is vastly better than one on which he gets five right and two wrong out of a total of seven.

Recent texts contain a large number of review exercises not only at the end of the book but also at the end of chapters. Here cumulative as well as chapter reviews are given. Such lists are very valuable and are often carefully prepared. They should be divided into graded sets to meet individual differences.

SYSTEMATIC INSTRUCTION IN PROBLEM SOLVING

Systematic instruction in problem solving is a characteristic of the newer texts. By this is meant the classification of problems according to subject matter and for each type of problem a clear statement of the meaning of the terms used and of the subject involved, together with a detailed development of the method of solving followed by carefully graded sets of problems. In contrast to this the lists of problems in the older books were merely sets of puzzles.

In the ten books studied, time, rate and distance questions were treated in this way in nine books; coin questions, lever questions and mixture questions each in seven books; work questions in six. In most books in which formulae appear as a distinct

topic at the beginning of the course, problems solved by a geometric formula are carefully discussed with the introduction of that formula. This includes perimeters and areas of rectangles, triangles, and circles and the areas and volumes of retangular solids. Interest questions are also included. This work is given at the beginning in as much as pupils may be supposed to have had preliminary work on these subjects in the elementary schools, or in the junior high school. One book only gave no adequate instruction in problem solving.

When one considers that there are a much larger number of pupils in the ninth grade than ever before and that an increasingly large proportion of them have little or no scholastic inheritance while others for one reason or another do not profit by the work as given fifteen or even ten years ago, one wonders why more classes of problems should not receive treatment of this kind. In the ten books studied digit problems were separately treated in only five books and consecutive number problems in only three. Number problems should be introduced at the beginning of the course by a series of translation questions intended to acquaint the pupil with the use of algebraic shorthand. This should precede problems that are really only number questions dressed up in some concrete disguise. Many authors do not do this. They seem to forget the composition of ninth grade classes as suggested above. They seem to forget also that the solution of problems is and always was the hardest thing for beginners in algebra.

PICTURES AND DIAGRAMS

Recent texts contain not only a larger number of diagrams than the older books but also numerous pictures. Although these pictures are intended to show the uses to which mathematics in general and algebra in particular may be put, there is often no indication either in the context or in the legend beneath the picture as to what that particular picture has to do with the subject. Maybe authors forget that they are writing an algebra, not getting out a picture book.

In general it is evident that authors of recent books appreciate to some degree, at least, the necessities of present day conditions. One wonders, however, if the books are advancing as fast as even the conservatism of schools and teachers would permit.

THE LAST WORD IN TELEPHOTOGRAPHY

By John Mills
Bell Telephone Laboratories, New York

Underlying all the electrical arts of communication—and these include not only telegraphy and telephony but also telephotography, television, and sound pictures—are a few basic principles. To appreciate those fundamentals is to possess a pass key which opens to ready understanding systems of communication which at first thought appear to have no essential in common. Whether the medium is wire or wireless, whether the signals which convey the information are audible or visual, there is a unity to all the communication arts. However different their devices and contrivances may seem to be, all of them are merely means for performing one or another of six typical operations. Four of these operations are essential to any system of communication and the other two to all except the simplest systems.

The four necessary functions of the parts in any system for communication are most obvious. First if intelligence is to be conveyed from one place to another there must be a generation of some effect which can be transmitted. Then, this something which can be transmitted must be varied so as to embody in its variations the intelligence which is to be transferred. The current, in other words, which has been generated must be modulated in accordance with the signal, or speech, which is to be transmitted. The next function is transmission; and the final one, the detection of the intelligence—an operation the inverse of modulation which is, therefore, called demodulation.

If at any point along the route of transmission the effect would be too feeble for easy recognition it must be amplified. The operation of amplification, although not involved in the simplest of systems, is of importance in most practical systems.

Similarly of practical importance is the sixth and last of the functional operations, that of selection. Whenever the medium through which transmission is to occur carries simultaneously more than one stream of intelligence, then selection is necessary at the receiving terminal In radio, since all communication is through a common medium, and in wire, whenever multichannel transmission is desired, each stream of intelligence is carried by a distinctive current. Each stream arises from an individual generator the output of which is modulated by the

particular signal or speech it is to carry. The separate streams can be selected one from the other by virtue of the distinctive characteristics of their respective "carrier" currents.

Generation, modulation, transmission, selection, demodulation, and amplification—these describe all the operations essential to any electrical system for the communication of intelligence. When analyzed for these functions, the simple circuit of an electric bell, with its battery and push button, and a very complex system like that for the simultaneous transmission over a single pair of wires of a score of telegraph messages and three or more telephonic conversations, display common qualities. It makes no difference, so far as concerns the types of operation which are required, whether the signal is audible or visual, whether it is conversation or image which is to be transmitted. An illustration of this fact is to be found in the system for the transmission of pictures which Bell Telephone Laboratories has recently developed.

Before that very interesting and ingenious system is described the unity of principle which runs through the communication arts may well be traced through telegraphy and telephony, both by wire and by radio. In the telegraph circuit of Morse a battery was the generator of a direct, that is, zero-frequency, current which was modulated at a low rate by the hand operation of a telegraph key. An electromagnet, as a sounder, detected the variations which the key introduced in the current. In the telephone circuit of Bell a similar zero-frequency current was modulated but at the higher rate which corresponded to the pitches of the sound waves of air which were impressed upon the diaphragm of the transmitter. At the receiving end of the telephone circuit the electromagnet, instead of reproducing the motion of a key, reproduced by its diaphragm the vibrations of the transmitter diaphragm; and thus established waves in the adjacent air similar to those at the sending station. Both inventors, it is to be noted, employed a zero-frequency current, one to modulate it with a frequency of a few cycles a second, or even less, and the other with a band of frequencies corresponding to the tones of the voice.

Communication systems, however, are not limited to the use of zero-frequency currents. A method for producing high-frequency currents was developed by Hertz and employed by him in his discovery of electromagnetic waves. He also developed a method for the detection of such waves. Their utiliza-

tion in radio telegraphy followed the inventions of Marconi. Equipment is arranged so that a high-frequency current is produced under the control of a telegraph key; the current, in other words, undergoes modulation at the low frequency of hand operation. When the modulated current flows in an antenna electromagnetic disturbances occur in the surrounding space and radiate to distant antennas where they establish similar currents.

Almost immediately the possibility of radio telephony became apparent, but it was not to be successfully accomplished

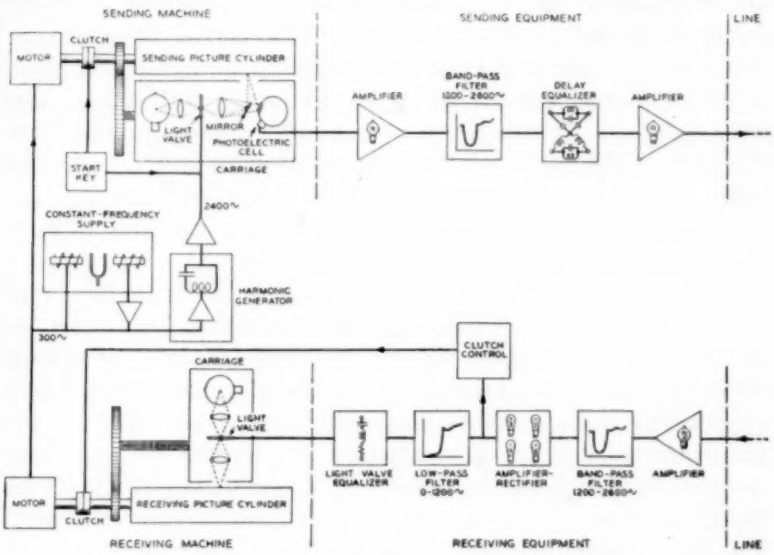


FIG. 1. Telephotograph System. Sending and receiving equipment for one station.

over considerable distances until 1915, at which time Bell Telephone engineers demonstrated the system they had developed by radio telephone transmission from Washington, D.C. to Paris. An essential in that system was the operation of amplification. A small current of high frequency was generated; this was modulated at audible frequencies by the current from an ordinary telephone transmitter; and the result of that modulation, amplified to the proper power, was then fed to the transmitting antenna. For transmission through space high-frequency currents were required; for guided transmission over wires low, or even zero-frequency, currents sufficed. Either type of current

could be modulated at either the low frequency of telegraphy or at the higher frequency corresponding to audible tone.

When transmission was unguided, as in radio, selection was necessary at the receiving terminal in order to pick out from the multi-channel ether the radiation from a particular station. The criterion of selection was the frequency (or, from another point of view, the wave length) of the high-frequency disturbance which carried in its modulation the intelligence which was being transmitted.

All these functional operations, from generation to selection, are involved in the picture-transmitting equipment recently designed by Bell Telephone Laboratories. In the transmitting equipment a narrow beam of light falls on the picture which is to be sent; and the latter moves continuously so that the beam scans successively all the tiny areas which compose it. From the picture the beam is reflected into a photoelectric cell. The reflected light varies in amount from instant to instant, according to the relative light or shade of the elemental areas of the picture upon which the beam falls.

In this part of the system one meets again the essential operation of generation, in this case, the production of a light; of modulation, in this case, at the relatively low frequency with which the successive areas are scanned; of transmission, across only a few millimeters of space, it is true; and then in the photoelectric cell of demodulation, or translation, whereby there is produced in the cell a current with variations of intensity identical to those of the reflected beam. The cell detects the light variations and gives rise to corresponding current variations. What it receives as light it translates into a current which can proceed along wires.

Before the current so proceeds, however, amplification is introduced. This is necessary because the current variations produced by the photoelectric cell are so small that they could easily be obscured by any interfering currents which the circuit might pick up inductively. Before the message bearing-currents of the cell start on their long journey they are made superior, by amplification, to the contaminating influences of neighboring circuits.

The amplified current then proceeds along the line to the distant terminal. In the receiving apparatus at that point one meets again the familiar elements of a communication system. There is, first, a generator for a beam of light. This beam, after trans-

mission through a few millimeters of space, falls as a tiny spot of light upon an unexposed photographic film. Before it reaches the film, however, it is modulated, or varied, so as to involve in its varying intensity the intelligence which is to be conveyed. This modulation is accomplished by the current from the distant sending apparatus. A delicate shutter, electro-magnetically controlled by the current, and intervening between light source and film, varies the light in accordance with the variations of current. What reaches the film, therefore, is a beam of light modulated to correspond to the light and shade in successive areas in the original picture. The process of demodulation is accomplished chemically in the film emulsion. There the actinic action, at each instant, corresponds in amount to the light intensity of the beam. In effect, the intelligence, which is embodied in a varied light beam, is translated into a chemical medium. The final detection of the intelligence awaits the chemical development of the film.

The film, which is being exposed at the receiving station, and the picture, which is being scanned at the transmitting station, must, of course, be moved in precise synchronism. How that is accomplished is not a necessary part of the present story. It is obvious, however, that—although it may require considerable ingenuity to accomplish it—all that is required is that the motors which drive respectively the picture and the film shall run at identical speeds and start at the same instant.

Of particular interest in this method for transmitting pictures is the number of times translations of intelligence occur, that is the number of media through which transmission takes place. The original intelligence resides in the pattern of light-reflecting powers which the picture displays. Transmission in the first instant is by light waves and these are modulated in accordance with this pattern. The demodulation which then occurs is not one which makes the pattern immediately intelligible to a human eye but is a translation from the medium of light to that of an electric current. Transmission is next by wire, at the end of which a new modulation is accomplished, translating the intelligence from current to light. The final step of demodulation involves the translation of the light variations into corresponding chemical variations of the surface of the film. The pattern of light-reflecting, or light-transmitting, powers thus established on the film, is intelligible to the human eye in the same way, and produces the same effect, as the original picture.

Such, in simple terms, is a description of the newly developed system for transmitting pictures; but that description has passed lightly over a further and more interesting illustration of the general principles which this article would emphasize. In the previous description nothing was said about the character of the light beam which is generated for scanning the picture. By implication it was a steady beam of light; actually such is not the case. What sort of a beam it is, and why, will now be explained.

The picture which must not be larger than 11×17 inches, is mounted on a drum 12 inches in circumference and 17 inches long. It is driven by a screw with twenty-five threads to the inch through a four-to-one gear so that the drum turns a hundred times while progressing one inch axially. It moves this inch in one minute. Seventeen minutes are thus required for scanning the maximum size of picture. A beam of light from a stationary source falls upon the picture in a spot about one-hundredth of an inch square, and scans it in a series of adjacent lines one-hundredth of an inch wide. The smallest area, as to the light and shade of which the photoelectric cell can report to the distant receiving station, is one-ten-thousandth square inch.

Imagine in any picture—what might be true—that successive areas of this size, which the beam scans, are alternately light and dark. Then the reflected light will pass through alternate maxima and minima, with one cycle for each two adjacent elementary areas; and similarly will the current in the photoelectric cell. This is the most rapid variation which is possible; and its frequency is half the number of elemental areas which the beam scans in one second. Because the beam scans twelve square inches each minute, each containing 10,000 elemental areas, it covers 120,000 of them in a minute, or 2000 in a second. Hence, the highest possible frequency for the current is one thousand cycles per second.

That is the maximum frequency. The minimum frequency which would exist when the picture was uniform in tone can be computed as follows: The largest picture can occupy eleven-twelfths of the drum, the remainder is allowed for clamps to hold the picture. The light beam scans a line eleven inches long before it falls on the clamps. For 11/20 second it scans the picture and for the next 1/20 second it falls on the clamps. In 12/20 of a second, therefore, the reflected beam would pass through a cycle of maximum and minimum intensity. That

means a frequency of a little less than two cycles per second.

The ordinary picture involves all conditions between these two extremes, and so may introduce modulation at any frequency from almost zero to 1000 cycles per second. It is difficult, however, to transmit all frequencies of that band with the same efficiency; but it must be done if the light and shade of the picture are to be faithfully reproduced at the receiving station.

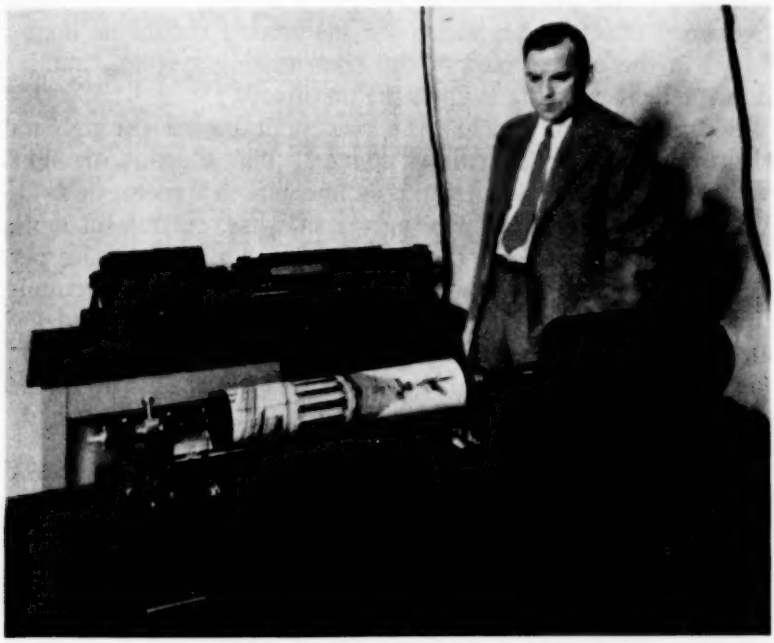


FIG. 2. In foreground, transmitting machine with a picture in place ready to be sent. In background, receiving machine.

Now it happens that the frequencies which a telephone line ordinarily transmits, without undue discrimination, lie in a range from about 200 to 2800. That meets the requirements of intelligibility and naturalness. If the thousand cycle band required by a picture extended not from zero to 1000 but from 1400–2400 its transmission could be easily and adequately accomplished by a properly arranged telephone circuit. The designers, therefore, arranged that the band of frequencies, which represents the variations in light and shade of the picture, should be transmitted as a band extending from 1400–2400.

In earlier telephoto equipment, which the Bell System put into service about 1925, this was accomplished by the method of carrier-current operation, using a high frequency for the carrier and modulating it with the current from the photoelectric cell. As will be recognized from the previous discussion, this is similar to the method of radio telephony where a high-frequency current is modulated by the audio-frequency current from a transmitter. Instead, however, of doing it this way the designers of this particular apparatus arranged that the high frequency effect which was to be modulated should be introduced in the optical part of the transmitting system, that is, into the light which falls upon the picture.

Before the light reaches the picture it passes through an electromagnetically-controlled shutter. The shutter, or light valve, as it is called, is formed by a fine wire in a magnetic field. When current flows the wire moves sidewise, cutting off more or less of the light from the lamp. Current of 2400 cycles per second is supplied to the wire from an oscillator of the vacuum-tube type. The valve, therefore, oscillates at the same frequency and produces corresponding variations in the intensity of the light which passes through it. When this beam falls upon the picture it is modulated in conformity with the light and shade of successive elementary areas.

The current from the photoelectric cell follows exactly the variations in intensity of the light beam. The current, therefore, is an alternating one of 2400 cycles per second, and its strength undergoes variations at the lower rate at which the details of the picture are scanned. There is, however, another way of considering this current—and there is simple triogonometry in substantiation of it. It may be resolved into, and hence considered to be composed of, three components. One of these is a current of steady strength and frequency 2400 cycles. The other components are, respectively, higher and lower than that frequency; and vary in strength in accordance with the light and shade of the picture. The frequency of one of these components is above 2400 cycles by a number of cycles, corresponding, at any instant, to the frequency introduced by scanning successive areas of the picture. The other component has a frequency correspondingly below 2400 cycles. Since all frequencies which the picture elements can introduce lie between zero and 1000 cycles the "side band" currents, which have just been described, will have frequencies in the ranges 2400–3400 and 1400–2400 respectively.

The intelligence, or signal, which is to be conveyed from the picture is involved in these three components of the modulated carrier current. For its interpretation, however, both side bands are not necessary. One side band and the carrier are sufficient. In the system under description, therefore, only the lower side band is transmitted. This is accomplished by introducing into the circuit, immediately following the photoelectric cell, an electrical filter which allows to pass only currents whose frequencies lie in the band 1200–2600.

The carrier current and its lower side band then proceed to the receiving station. Amplification is introduced as necessary along the route. At the receiving station this current is demodulated giving rise to a current, of frequency zero to one thousand cycles, which is proportional at each instant to the light and shade of an element of the distant picture. This current operates a light valve, similar to that which is used at the sending station, which is interposed between a steady lamp and an unexposed film. Through its action the amount of light which falls on the film is varied from instant to instant in accordance with the light and shade of a corresponding area of the original picture.

From the standpoint of practical engineering there are many advantages to this recently developed system. From the standpoint of pedagogy, however, it appears to the writer as especially interesting because it illustrates so completely, and in such a variety of ways, the fact that all systems of electrical communication are constructed around six fundamental operations of generation, modulation, transmission, demodulation, amplification, and selection.

NEW HOST OF VARIABLE STARS REPORTED BY HARVARD ASTRONOMER

Seventeen hundred hitherto unreported variable stars, 1,000 in the Small Magellanic Cloud and 700 in our own Milky Way galaxy, were reported by Prof. Harlow Shapley, director of the Harvard College Observatory, in one of his periodic comprehensive reports on the astronomical state of the universe as seen through telescopes. Prof. Shapley spoke before the meeting of the National Academy of Sciences. These newly located stars will give us a better idea of the great aggregations of the star-studded nebulae that dot space as far as telescopes can reach.

In addition, thousands of faint and remote galaxies, each a cloud of thousands of stars, have been discovered, Prof. Shapley reported. The Harvard census of new faint galaxies now totals 125,000, with about a third of the sky covered and only galaxies lying between about fifty and a hundred and fifty million light years away included.—*Science Service.*

THE FIELD TRIP IN BIOLOGY

By Fred M. Schellhammer
Evander Child's High School, New York City

In the biological sciences, the field trip has long been recognized as a teaching device since it presents the material studied in its natural environment and allows for direct observation and interpretation of the material in its specific surroundings. This recognition of the utility of the field trip has seldom had objective justification. Does the field trip actually aid our classroom work or are our commendations of it purely subjective? The following study which took place over the period of a year in a New York High School is an attempt, on a small scale to answer that problem from an objective viewpoint. A summary of the study follows:

Summary:

The writer's purpose in attacking the problem was to find out whether the field trip in biology could be used satisfactorily as a device to increase learning as measured by the ratings achieved on the part of the pupil. The problem was approached in the following manner:

Selection of Pupils:

Two groups of incoming freshmen in a New York City High School were selected on the basis of the "Otis Mental Ability Tests." The groups, designated as "A" and "B" each consisted of two hundred and one pupils although later in the experiment the number dropped to one hundred and ninety-four. Group "A" had an Intelligent Quotient average of 103.75 and group "B" an Intelligence Quotient average of 102.09.

Method:

The rotation technique was used. It aided in eliminating or equalizing inequalities between the groups and provided the

Periods (experiment)	Variables	
	1	2
I	Group A	Group B
II	Group B	Group A

Variable I: the classroom work.
Variable II: classroom work supplemented by Field Trip.

writer with more pupils for his experiment. The method, then, was based on the use of two parallel groups in which the variable was applied first to group "B" and then to group "A."

A diagrammatic outline of the method would be expressed as in the diagram above.[1]

Expressed in symbols the method may be explained as follows:

$G_A \cdots I.\ T. \cdots V_1 \cdots T_1 \cdots Ch_1 \cdots V_2 \cdots T_2 \cdots Ch_2$
$G_B \cdots I.\ T. \cdots V_2 \cdots T_1 \cdots Ch_1 \cdots V_1 \cdots T_2 \cdots Ch_2$

in which:

G_A is the control group in the first unit of the experiment and the experimental group in the second experiment.

G_B is the experimental group in the first unit and the control group in the second.

$I.\ T.$ is the initial test given to both groups before each teaching period.

V_1 is the control factor or the group given the classroom work.

V_2 is the experimental factor or the group given the classroom work supplemented by the Field Trip.

T_1 and T_2 are the final tests given at the end of each unit of work.

Ch_1 and Ch_2 are the differences between the results scored in the initial and end tests of each unit of work.

Testing Unit:

As a means of measuring the results of the experiments the "Blaisdell Instructional Tests in Biology" were used. In the first experiment the test "Leaves and Their Functions" was applied and, in the second experiment, the test "Flowers and Fruits" was used. The tests were used both as initial and final tests.

Teaching Units:

The teaching units were constructed by the writer on the basis of the New York State Syllabus in Biology. The units were so organized that the control group would receive five forty-one minute periods of classroom instruction on the topic and the experimental group four forty-one minute periods of classroom instruction, and, in addition, one forty minute field trip. A Field Trip Guide was constructed for use in the field trip.

[1] *The Technique of Research in Education*, Claude C. Crawford, University of Southern California Press, 1928.

Procedure:

The initial tests were given both groups and the teaching unit applied, the Field Trip being withheld from the control group. The final test was then given and the changes noted. The groups were then reversed, the control group becoming the experimental group and the experimental group the control. The second unit was then taught and again the changes noted.

Results:

A summary of the results of the two experiments showed the following:[2]

EXPERIMENT 1. "LEAVES AND THEIR FUNCTIONS"

Group	Students	I.Q.	I.T.		F.T.		M.I.
		(av.)	M.	S.D.	M.	S.D.	
A (control)	201	103.75	7.86	4.03	33.83	5.86	25.97
B experimental)	201	102.09	6.89	4.26	36.49	5.20	29.6

EXPERIMENT 2. "FLOWERS AND FRUITS"

A (experimental)	194	103.75	7.53	3.73	35.75	5.37	28.22
B (control)	194	102.8	6.71	3.74	33.12	5.78	26.41

In the first experiment the Difference of Mean Improvement was 3.63.

In the second experiment the Difference of Mean Improvement was 1.81.

From the summaries it is evident that, in both cases, the group receiving the field trip instruction did better than the group which received the classroom instruction alone. In the first unit of work the experimental group averaged 3.63 more correct answers out of fifty on the test than did the control group; in the second experiment the experimental group aver-

[2] I.T.: Initial Test. F.T.: Final Test. M.P.: Mean Improvement. S.D.: Standard Deviation.

aged 1.81 more correct answers out of fifty than the control group. The experimental coefficients (in the first case 2.4 and the second 1.62) indicate practical certainty that results in favor of the experimental group would be achieved with other samplings of students.

A further study of the range of scores seemed to indicate that the field trip was especially beneficial to the "slower" pupils since, in both experiments, the group receiving the experimental factor had fewer scores below twenty-five than it did when used as a control group.

Conclusions:

The field trip was successful as a device for increasing the learning process as measured in terms of pupil ratings.

The results scored in the two experiments show an increased average rating per pupil when the group was used as an experimental group. The experimental coefficients confirm the fact that like increases would be found in larger samplings.

ANOTHER QUANTITATIVE EXPERIMENT FOR HIGH SCHOOL CHEMISTRY

By Druley Parker

Shortridge High School, Indianapolis, Indiana

The *formula* of copper oxide is determined by reducing it with illuminating gas. The apparatus consists of an ordinary $\frac{5}{8}''$ test tube, ring stand and clamp, 8″ piece of 6 mm. glass tubing, 3 ft. of rubber tubing and a Bunsen burner. From 2 to 3 grams of copper oxide is introduced into the weighed tube and the weight of the tube and contents determined. The 8″ piece of glass tubing is placed in the end of the rubber tubing attached to the ordinary illuminating gas supply. The glass tube is introduced into the test tube and contents, which has been clamped into a horizontal position on the ring stand. The gas is gently turned on and lighted at the mouth of the test tube. The flame is regulated to a height of about four inches. The tube and oxide are heated by means of the Bunsen until the whole mass glows and reduction is complete. This requires about three to four minutes. At the end of this time the Bunsen is removed and the gas allowed to continue burning at the mouth of the tube until the copper has cooled to room temperature and then the

flame at the mouth of the tube is extinguished. After thoroughly cooling, the test tube and copper are weighed. All weighings are made to a centrigram only. The following data were obtained by a class which had previously performed only one quantitative experiment.

Student No.	*Gms. Cu Found*	*Gms. O Found*	*Gm. Atoms Copper*	*Gm. Atoms Oxygen*
1	2.03	0.50	0.032	0.031
2	1.84	0.35	0.028	0.021
3	1.515	0.37	0.024	0.023
4	2.19	0.55	0.034	0.034
5	1.55	0.37	0.024	0.023
6	2.05	0.54	0.032	0.033
7	1.99	0.48	0.031	0.030
8	2.20	0.54	0.035	0.034
9	1.62	0.39	0.025	0.024
10	1.93	0.38	0.030	0.023
11	1.38	0.36	0.021	0.022
12	2.40	0.58	0.038	0.036
13	1.46	0.36	0.023	0.023
14	1.39	0.37	0.022	0.023
15	2.46	0.65	0.039	0.040
16	1.07	0.27	0.017	0.017
17	1.47	0.35	0.023	0.022
18	1.63	0.54	0.025	0.032
19	1.42	0.36	0.022	0.022
20	1.73	0.38	0.027	0.024
21	1.41	0.35	0.022	0.022
22	1.32	0.34	0.021	0.021

It is obvious from the results that the formula of cupric oxide should show equal numbers of atoms of Cu and of O or $(CuO)_n$.

The only difficulty with this experiment is that pure cupric oxide is hard to find on the market.* The cupric oxide used was prepared by precipitating basic copper carbonate by the addition of sodium carbonate to a solution of cupric nitrate, as described in "Synthetic Inorganic Chemistry." by Blanchard and Phelan. The precipitated sludge was heated to boiling for one hour when it turned black and settled rapidly. It was washed repeatedly by decantation, filtered, dried and then gradually heated to the highest temperature of the Bunsen for at least one hour. During the dehydration and decomposition of the basic carbonate, contained in a casserole, it was repeatedly stirred. A preliminary test should be made by the instructor to see that the material gives the correct formula.

* We found plenty of samples that were free from other metals but they always contained both cuprous and cupric oxide and usually plenty of water. We have recently found that the Coleman & Bell Co., Norwood, Ohio, can furnish a satisfactory C.P. copper oxide.

SIMPLE PROOFS FOR SIN (A ± B), COS (A ± B)

By L. Richardson

The University of British Columbia, Vancouver, Canada

For students who possess a knowledge of the formulae of analytical geometry,

(α) $\Delta = \frac{1}{2}[x_1(y_2-y_3)+x_2(y_3-y_1)+x_3(y_1-y_2)]$

(β) $d = \sqrt{(x_1-x_2)^2+(y_1-y_2)^2}$

the following proofs of the formulae for

$$\sin(A \pm B),\ \cos(A \pm B)$$

will be very easy to follow. For all angles A and B we take the initial line for each along the positive X axis.

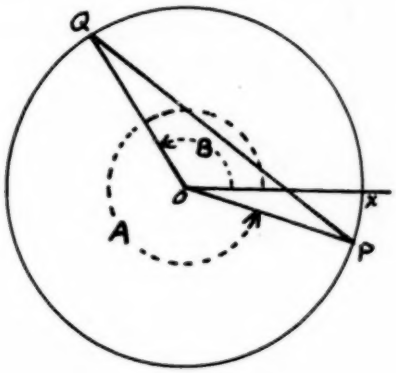


Fig. 1

In figure 1 the circle is of unit radius. Angle XOQ is B, and Q is the point $(\cos B, \sin B)$. Angle XOP is A, and P is the point $(\cos A, \sin A)$, for all angles A and B.

Now $\cos(A-B) = \cos POQ$ of the triangle POQ in all cases since $\cos(360-x) = \cos x$. That is

$$\cos(A-B) = \frac{OP^2+OQ^2-PQ^2}{2OP \cdot OQ}$$

$$= \tfrac{1}{2}\{2-[(\cos A-\cos B)^2+(\sin A-\sin B)^2]\}$$

$$= \cos A \cos B+\sin A \sin B.$$

Using the same figure we have,

$$\text{Area of triangle } POQ = \tfrac{1}{2}OP \cdot OQ \sin [360-(A-B)]$$
$$= -\tfrac{1}{2}\sin (A-B). \qquad (1)$$
$$\text{By formula } (\alpha) \text{ this area } = \tfrac{1}{2}[\cos A \sin B + \cos B(-\sin A)]$$
$$= \tfrac{1}{2}[\cos A \sin B - \sin A \cos B]. \qquad (2)$$

Equating (1) and (2) we have,

$$\sin (A-B) = \sin A \cos B - \cos A \sin B.$$

To derive independently the formulae for $(A+B)$ we take any two angles B and $-A$ as shown in the accompanying figure (fig. 2).

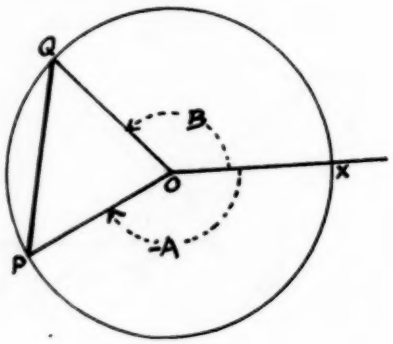


FIG. 2

Then the angle POQ measured in the positive direction is $(A+B)$. In the triangle POQ we have

$$\cos POQ = \cos [360-(A+B)] = \cos (A+B).$$

Hence

$$\cos (A+B) = \frac{OP^2+OQ^2-PQ^2}{2OP \cdot OQ}$$
$$= \tfrac{1}{2}[2-(\cos B-\cos A)^2-(\sin B+\sin A)^2],$$
$$= \cos A \cos B - \sin A \sin B.$$

Using the same figure we have

$$\text{Area of triangle } POQ = \tfrac{1}{2}OP \cdot OQ \sin [360-(A+B)]$$
$$= -\tfrac{1}{2} \sin (A+B). \qquad (1)$$

Also the area of POQ is equal to

$$\tfrac{1}{2}[\cos B \sin(-A)+\cos A(-\sin B)] \text{ by formula } (\alpha),$$

$$= -\tfrac{1}{2}[\sin A \cos B+\cos A \sin B]. \quad (2)$$

Equating (1) and (2) we have

$$\sin(A+B)=\sin A \cos B+\cos A \sin B.$$

The above proofs are quite general and the author has found that they are easy to teach.

NOTE: When the angle $A \pm B$ is an angle of the triangle POQ the proofs are a little shorter as the reader can easily verify.

GAME RESTORATION FOSTERED IN COMBATING SOIL EROSION

Game birds and animals are being increased in numbers as a profitable by-product of the Government's war against soil erosion. At the meeting of the American Game Conference at New York, January 21, Ernest G. Holt, chief forester of the U.S. Soil Erosion Service, told of encouraging results already achieved as a beginning, and of further steps that can and should be taken as the work matures.

Growing trees, shrubs and smaller plants will be the main reliance for anchoring the soil after the worst gullying has been checked by dams and other engineering devices. These plantings, Mr. Holt said, are being selected with special thought to their value as game cover and food sources. Further steps to insure success will include continued scientific supervision and cooperation with other agencies, especially state and local authorities; encouragement of wildlife research, and maintenance of strict scientific standards; preferential treatment for native game species; and efforts to promote the highest possible standards of sportsmanship.

As a concrete example of results already accomplished, Mr. Holt cited the case of the Coon Creek erosion project in Wisconsin, which has now been in operation for a full year. Here the quail population has been brought through a winter with practically no losses, and the total stock of these birds nearly doubled. Plantings have included 55,500 trees and shrubs of special value for wildlife food and cover, 330,000 conifers that will directly benefit ruffed grouse, 200,000 hardwood trees good for cover and some food, and 330 food patches in millet, sorghum and other plants of food value to the birds.

The coming spring, the speaker added, will see wildlife work, under the direction of competent biologists, in full swing on seven demonstration areas, with others to follow as soon as the work can be organized.

—*Science Service.*

RADIO RECEPTION AND THE SUN-SPOT CYCLE*

By Harlan True Stetson
Institute of Geographical Exploration, Cambridge, Mass.

The interrelation between solar phenomena and terrestrial matters we may regard as one of the most fascinating and fruitful fields of scientific research in the realm of cosmic physics. A recurrence at more or less definite intervals of periods of sun-spots now on record for some three centuries leaves little doubt as to the reality of a solar cycle. The concomitant variations in terrestrial magnetism and the appearance of aurorae have become sufficiently well established to leave little doubt as to an intimate relationship between changes in solar activity and electromagnetic conditions on the earth.

It is, however, chiefly during the last solar cycle, whose beginning may be placed at the sun-spot minimum of 1923, that quantitative measurements of radio transmission have made possible a new tool for the investigation of the effects of changing solar phenomena upon the ionization of the earth's atmosphere. Results of investigations of recent years both in the United States and in England seem now to have established beyond much doubt an intimate relationship between variations in solar activity as indicated by sun-spots and the corresponding changes in the height of the Kennelly-Heaviside layer responsible for the long distance transmission of radio waves. Opinions may differ in detail as to the exact mechanism by which radio waves are propagated from one point to another along the earth's surface. The present state of our knowledge, however, leads us to suppose that, except for the transmission of the ground wave which figures conspicuously in distances generally less than 100 miles, the electromagnetic waves of radio spread in all directions from the antenna to the upper atmosphere where they encounter the ionization layer postulated independently by Kennelly of the United States, and Heaviside of England, from which they are turned back earthwards. In tracing the effect of the known changes in solar activity upon radio transmission, it may be well for the moment to review briefly the essential structure of the earth's atmosphere especially in the region where presumably changes in the direction of radio waves take place.

* Adapted from address at Fifth Pacific Science Congress printed in its proceedings, Toronto, 1934.

The greater part of the air mass is contained within the lower atmosphere, or troposphere. Here temperature decreases almost uniformly with altitude to −55°C. at the 12-kilometre level, above which the temperature may be considered practically uniform. At an altitude of 50 kilometres, which approaches the region conspicuously involved in the transmission of radio waves, atmospheric pressure decreases from less than 0.5 millimetres of mercury to a vanishingly small amount at a height of 200 to 300 kilometres, the usual extremity of auroral arches. It is in this upper region of the stratosphere at altitudes of 100 to 200 kilometres that ionization conditions appear most favourable in connection with radio wave propagation. The mean free path of neutral and ionized molecules, which, under standard conditions of temperature and pressure at the earth's surface, amounts to approximately 6×10^{-6} centimetres, attains values of many metres or possibly kilometres. The long free paths would seem to preclude the possibility of any appreciable electrical field in the ionized portion of the stratosphere. Any attempt at the creation of a field under these conditions should result in its dissipation through the immediate displacement of charges.

While direct measurements of atmospheric ionization are possible and have been made up to heights of 15 kilometres, ionization at greater heights can be determined only from analytical considerations involving the rate of absorption of external radiation and the probability of recombination of ions and the number of free electrons present. The close dependence of such factors on conductivity and the propagation of radio waves of various wave-lengths has made possible fair determinations of characteristics of the region from 80 to 100 kilometres. A remarkable agreement has resulted from radio data of observations of meteors, aurorae, and terrestrial magnetic phenomena.

In considering the sources of ionization in the region of the upper atmosphere, consideration must be given to the energy absorbed from all outside sources, particularly the sun, the stars, and interstellar sources of cosmic radiation. Since a fair estimate of the integrated energy of starlight is of the order of 10^{-3} times that of the sun, this source may be considered from the point of view of radio transmission phenomena very sensibly negligible. While cosmic rays evidently appear to be of increasing consequence in atmospheric ionization, the near constancy of

ionization from this source appears to introduce no important factor so far as periodic or cyclical changes in radio transmission are concerned.

The most obvious dependence of changes in radio reception upon solar radiation becomes apparent in considering the marked changes which occur between day and night reception, the optimum frequencies for transmission varying markedly between daylight and darkness. The notable ability of ultra-violet light as an agency in the ionization of gases has led to the rather generally accepted belief that the ultra-violet region of the solar spectrum is most conspicuously responsible for the creation of the ionized region in which the Kennelly-Heaviside layer is postulated.

Pederson[1] believes that most calculated values of atmospheric ionization which have been based on an assumed value of the solar constant 1.35×10^6 ergs/cm.^{2} sec., a solar temperature of 6000°K, and a black body distribution for the radiation, may lead to values far too low, since the justifiability of a black body distribution appears doubtful. He proposes the electrons, ions, and alpha particles expelled from the sun's interior, ionize the upper part of the solar chromosphere exciting in turn powerful radiation in the extreme ultra-violet far beyond what could be expected on the basis of black body distribution. Some basis for confirmation of such an hypothesis may be found in the circumstance that the measured conductivity of the air appears about 50 per cent greater at sun-spot maximum than at sun-spot minimum.

Experimental results have shown that nitrogen and oxygen are easily ionized by ultra-violet light between 1800 and 1200 Å. The altitude of the Kennelly-Heaviside layer would then appear to be determined by the degree of penetration possible for these rays. Such ionization would then appear to exist from this critical level upwards to an extreme limit of atmosphere where a scarcity of ionizable material would again form a boundary. Such a picture Pedersen postulates, presupposing an ionized region extending from about 80 kilometres to several hundred kilometres above the earth's surface.[2]

Investigations by Appleton and his co-workers in England[3]

[1] *The Propagation of Radio Waves*, p. 74, Copenhagen, 1927.

[2] *Ibid.*, pp. 70-9.

[3] See, for instance, Appleton, E. V., *Proc. Royal Soc.*, vol. 109, p. 621, 1925; vol. 113, p. 450, 1926; vol. 115, p. 305, 1927; vol. 117, p. 576, 1929; vol. 126, p. 542, 1930; vol. 128, p. 134, 1930; vol. 128, p. 158, 1930.

utilizing the methods of phase interference, and those of Gilliland, Kenrick, and Norton of the United States Bureau of Standards[4] employing the pulse method, show corroborating evidence for the existence of two definite layers or regions of ionization, commonly known as the E and the F layers, from which the radio waves are turned back earthward. The E layer shows effective reflection up to frequencies of 3000 kilocycles at an average altitude of somewhat over 100 kilometres during the daylight hours. High frequencies from 4000 to 5000 kilocycles give similar response from a layer ranging from 200 to 300 kilometres in height. It is from the lower, or E layer, that the radio waves of broadcast frequency are returned earthwards.

The most obvious effect of solar radiation upon the ionization or electron density of these regions occurs in the transition of radio reception from day to night conditions, experienced by even the most unobserving attendant on the radio broadcasted programmes, distant reception being far superior during those hours of the day when the sun is below the horizon. Receiving sets beyond the range of the ground wave from the sending station depend for their reception upon the return earthwards of the sky wave. With the vanishing of sunlight and the consequent withdrawal of the chief ionizing agent of the upper atmosphere, dissociation is presumed to set in with a consequent rising of the effective layer height until some time after midnight, resulting in increased intensities of the carrier wave at the receiving end of the path.

A pioneer worker in the quantitative measurement of radio reception in the broadcast band is Mr. G. W. Pickard, of Boston, who first began systematic measurements of the intensity of the carrier wave of the broadcasting station of WBBM, Chicago, at his private laboratory in Newton Centre, Mass., in 1926. Studies of the early observations by Mr. Pickard indicated the possibility of the observed changes of intensity concurring with changes in solar activity as exhibited by the numbers of sun-spots.[5] Through the courtesy of Mr. Pickard, suitable equipment was installed at the Harvard Astronomical Laboratory in Cambridge, in 1928, so that unbroken records might be continued in connection with solar studies in progress throughout the current sun-spot cycle. These observations

[4] *U. S. Bur. Stan., J. Research*, vol. 7, p. 1085.
[5] *Proc. I.R.E.*, vol. 15, nos. 2 and 9, 1927.

were continued at this station until the fall of 1929 when the apparatus was removed to Delaware, Ohio, where a new series of records was begun with the initiation of the scientific programme of the Perkins Observatory, for which the writer was responsible. The task of continuing the Chicago-Boston series of measurements was then assumed by Professor G. W. Kenrick, at the Electrical Laboratories of Tufts College, Mass.

The data obtained by the work of Pickard and Stetson for 1926–9 show that the intensity of radio reception over the 900-mile path from Chicago to Boston was nearly inversely proportional to sun-spot numbers.

Observations began at the Perkins Observatory in March, 1930, and have continued daily with few interruptions throughout the present solar cycle. The results of the observations through 1932 have shown remarkable increase in the intensity of the carrier wave coincident with the rapid fall in sun-spot numbers which has ensued since the end of 1929, radio reception at the present time being from four- to five-fold greater in intensity than at the beginning of the present series which was near sun-spot maximum. The motions of the pen respond proportionally to the varying current in the grid circuit produced by the changing intensity of the carrier wave received. The recorder is in operation from 9.00 P.M. until 2.00 A.M., E.S.T., each night. Continuing the practice on the Chicago-Boston series, reductions have been made for the 9.00 to 10.00 hour each evening, the average values of the excursions of the pen during this interval being taken as the index for the intensity of radio reception for the night. The receiving apparatus is duly standardized each night by means of a standard oscillator tuned to the frequency of the broadcasting station (770 kilocycles), the observations for standardization being taken when the broadcasting station is off the air. Through the courtesy of the broadcasting station in Chicago, the Perkins Observatory received daily copies of the transmitter log, so that any variations of the antenna input could be allowed for at the receiving end.

The results of the study at Delaware from 1930 to 1933 substantiate the findings of the Chicago-Boston data. A further study appears to indicate that sun-spots near the sun-earth line are more clearly indicative of radio changes than the number of sun-spots taken over the whole solar disk.

Two hypotheses may be advanced to account for the appar-

ent effect of sun-spots upon radio reception. One, sponsored by Hulbert of the Naval Research Laboratories and others, favours the theory that there is an increase in the ultra-violet output of solar radiation concomitant with the appearance of sun-spots, and that this increase in ultra-violet radiation is responsible for an additional ionization of the terrestrial atmosphere effectively lowering the Kennelly-Heaviside layer, the lowering layer being less favourable to the transmission of the radio wave over the path in question. Another theory advanced by Appleton, Chapman, and others, is that corpuscles or particles are ejected from the sun in the neighbourhood of sun-spots, and that these sun-spots have a certain directive effect upon the ejected particles. In this case it is supposed that the arrival of sun-spots through natural solar rotation into the neighbourhood of the sun-earth line results in an excessive bombardment of the terrestrial atmosphere with an increase in ionization produced by collision of atmospheric molecules with the ejected solar particles. The question arises in this instance as to the nature of the corpuscles so ejected. There appear to be serious inherent difficulties in considering such particles electrons, as there appears to be at present no mechanism satisfactory to astrophysicists whereby negatively charged particles can continuously leave the sun. Some consideration can, perhaps, be given to the importance of considering neutrons or positrons in this connection. The discovery by Hale of the nature of sun-spots as electromagnetic whirls in the solar atmosphere, and as centres of powerful magnetic fields, would appear to imply some basis for an initial directive force in the emission of charged particles. Swann[6] has recently advanced the theory that sufficiently powerful magnetic fields may exist in certain sun-spots to propel electrons or positive particles with sufficient velocity to escape the solar atmosphere. If such a particle either positively or negatively charged, were to unite with a particle of the opposite sign in the neighbourhood of the sun, it appears plausible that such ejected corpuscles should find their way to the outer atmosphere of the earth, causing an increase in the ionization of the Kennelley-Heaviside layer without undue deflection poleward of the earth's magnetic field.

Remarkable studies of Störmer in connection with the phenomena of radio echoes[7] and of aurorae,[8] appear to give sub-

[6] *Phys. Rev.*, vol. 43, p. 21.
[7] *Proc. Roy. Soc. Edinburgh*, vol. 50, part II (no. 15), pp. 187-99.
[8] *J. Terres. Magn. and Atmos. Elec.*, pp. 375-88, Sept., 1932.

stantial evidence for the emission of charged particles from the sun, conspicuous during periods of sun-spot maxima.

In connection with our studies of radio reception and the varying numbers of sun-spots, it is to be noted that secondary fluctuations appear superimposed on the main 11-year cycle with approximate intervals of 15 months.

Since the actual observations here discussed have represented paths of relatively long distance on waves of broadcast frequency only, it is hardly safe to generalize as to conditions throughout other territories of widely different frequencies or path lengths outside until more extended data are available. It has been definitely shown by Pickard[9] and others that high frequency transmission may show the inverse effect from that exhibited in the broadcast zone. Furthermore, it is becoming apparent in the last few years that with improved conditions in the reception of the sky wave as a result of the supposed rising of the Heaviside layer and the decreasing solar activity, troublesome interference often ensues at receiving stations sufficiently near the sending station to intercept both the ground and the sky waves. A peculiar mushiness has been often observed during the last few years not apparent at sun-spot maximum in 1928–9, due to the fact presumably that in those years conditions were unfavourable for the reception of the sky wave with sufficient intensity to interfere seriously with the ground wave at distances less than 100 miles from the broadcast station.

The present status of our studies of radio reception and the solar cycle leads us to the conclusion that we may consider a relationship of some sort has been rather definitely established that emphasizes the need for more extended co-operation among various observers in the systematic and continuous recording of radio reception. If a sufficient number of co-operating observers could be obtained in the neighbourhood of established broadcasting stations occupying clear channels, it should become possible ultimately to construct daily maps with lines of equal radio intensity surrounding the several broadcasting stations selected, resembling the daily weather map in appearance. Studies of these areas of high and low intensity in radio reception, and their migrations, would probably do far more towards the solution of the riddle of solar and terrestrial relations than any number of isolated investigations could of themselves perform.

[9] *Proc. I.R.E.*, vol. 15, nos. 2 and 9, 1927.

A DUPLICATE WAVE APPARATUS

By Earl H. Schroer
Benson High School, Omaha, Nebraska

Recent trends in the application of wave motion to scientific development make a more intensive study of transverse waves for high school science classes desirable. Apparatus is available for demonstrating wave motion in its simplest form. Cathode ray oscillographs take care of the more complex phenomena, but this apparatus is not available in the majority of schools including the college and university. Interference of wave motion is easily demonstrated by light waves, radio waves, and sound waves, but the theory involved is usually confined to textbook illustrations.

There has long been a need for a device for presenting these phenomena in a manner that will result in a clearer understanding on the part of the pupil, of this particular phase of the subject. This led to the construction of a simple piece of apparatus (Figure 1)* which not only clearly illustrates the actual formation of beats but may be used for several other demonstrations.

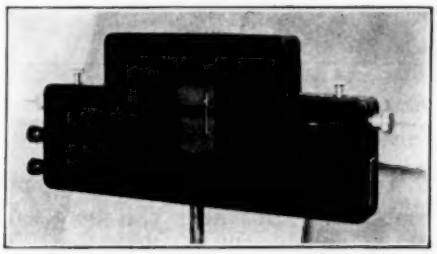


Fig. 1. General View of Apparatus.

This apparatus consists of two electrically maintained vibrating wires with variable frequencies of proper range. It is designed to fit the slide carriage of any modern stereopticon or the optical bench, (Figure 2) and the images of the vibrating wires are projected through a small vertical opening to a revolving mirror which provides the necessary horizontal spread. The same effect can be secured by replacing the objective lens of the projector with a lens wheel, but in either case the mirror or the lens wheel should have a controlled variable speed for the best results.

* This apparatus is now being developed by the Central Scientific Company of Chicago.

With one of the wires at rest and the other vibrating, the usual moving image of a transverse wave can be shown with a line of zero amplitude. Sychronizing the mirror speed with the frequency of the vibrating wire, one obtains a sine curve which can be held stationary on the screen. If the second wire is caused to vibrate at a slightly different frequency, a second wave image can be produced which will advance slowly past the standing wave clearly showing interference and reinforcement at regular intervals.

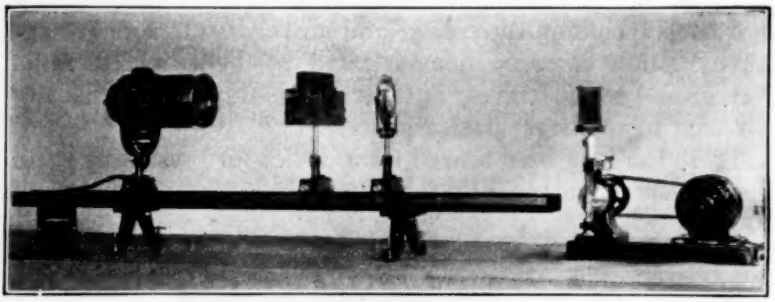


FIG. 2. An Optical Bench Set Up of Apparatus Using a Revolving Mirror.

In addition to the study of transverse wave motion and the formation of beats, the apparatus can be used to illustrate certain electrical phenomena. Through the proper speed control of the revolving mirror the effects of capacitative and inductive reactance in an electrical circuit are clearly shown. Commutation can be demonstrated by covering half of the horizontal opening and by regulating the frequency of the two wires. Further experimentation will develop additional uses for this apparatus.

With funds provided by the Swedish government, unemployed workers of Sweden are busily raising the walls and towers of historic Bohus Castle, of medieval fame.

Ruins of the castle have long been a landmark to travelers approaching Gothenburg from the sea. That the ancient stronghold was a center of Scandinavian military history from the time of the Middle Ages, has been a familiar fact. Now the secrets of the castle, its dungeons, powerful fortifications, and stately vaulted baronial halls, are being uncovered by the relief workers.

In one tower, a small museum has been improvised by the archaeologists in charge, and here cannon-balls, arms, and other grim souvenirs of battle are being deposited. When ready, Bohus Castle is expected to be one of northern Europe's proudest medieval monuments.

ORIGIN OF THE SOLAR SYSTEM

By W. T. Skilling
State Teachers College, San Diego, California

Well may the sun and its planets be designated the *solar* system—the system of the sun. The earth, which from our point of view is so important a part of the system weighs only one three hundred and thirty thousandth as much as the sun. And all the planets and satellites constitute only one seventh of one percent of the mass of the solar system. The sun makes up the other 99 6/7 percent.

It seems altogether natural that so heavy a mass as the sun should remain almost at rest in the center and that the planets should be swung around it, controlled by its enormous force of attraction.

But not only must the planets now look to the sun for control; in the beginning the whole external system is supposed to have had its *origin* in the sun. How far back that origin was has not yet been fixed with any degree of definiteness though there are a few separate lines of reasoning which may sometime yield a fair estimate. However long ago it may have been the earth and all of the planets were, according to all modifications of scientific theories as to their origin, a part of the sun.

Laplace, who originated the "Nebular Hypothesis," thought that the separation took place while yet the sun was in a highly expanded, nebulous, state so that as planet after planet was thrown off in the form of a ring by the revolving nebula it had only to wait for the sun to shrink away from it to be left an independent body. Then the ring would condense into a globe and the planet would be finished. Ring after ring of material was supposed to have been thrown off, or merely left behind, by the contracting sun, making one planet after another, each new one to revolve in a smaller orbit than the one that preceded it.

This theory posseses only historic interest now, for it has been found to be untenable in the light of modern knowledge of mechanics. In the first place, such rings as the hypothesis assumes would not condense into a single planet but into a multitude of meteoric particles like the material in the rings of Saturn, or into many rather small bodies like the two thousand or more asteroids between Mars and Jupiter.

A second objection to Laplace's theory is that the planets possess a much more rapid motion than could have been im-

parted to them by any original turning motion that the nebulous sun might have had. Expressed in another way, the planets possess altogether too much augular momentum in proportion to the augular momentum of the sun to make Laplace's theory reasonable. Calculation shows that nearly 98 per cent of the augular momentum of the whole solar system is in the planets, though they possess, as mentioned above only 1/7 of 1 per cent of the mass.

By augular momentum of a body moving around a center (also called its moment of momentum), is meant the product of its mass times its velocity times the radius connecting it with the center. (Augular momentum = mvr.) The unanswerable question is, how did it happen that the total amount of augular momentum of the system (which total cannot change) is now so unequally distributed, the sun, which has about 745 times the mass of the planets having little more than 2 per cent of this momentum.

No force within the system itself could have increased the total amount of augular momentum so it must be that some force from the outside supplied the planets with this form of energy which the sun does not now possess in any large measure and which it could scarcely have supplied so generously to planets.

The force that did this is now thought to have been the attraction of a passing star. Among the hundred thousand million stars estimated to comprise the whole stellar system, all of which are in motion, it is not improbable that sometimes one should pass close to another. And if two should thus pass it is certain that their mutual attraction would powerfully affect each other.

We know from observation that the moon, small as it is, raises tides upon the earth. The moon, which causes these tides, has but 1/80 the mass of the earth and therefore 1/80 as much attraction as the earth. Think what would be the attraction of a star even if no larger than the sun, remembering that the sun has 330,000 times the mass of the earth and therefore $330{,}000 \times 80$ times the mass of the moon. And if that much more mass then that much more attraction, at a given distance. Certainly if a star equal to the sun, and perhaps much more massive, as many stars are, should pass the sun within say the moon's short distance from it, the tide that it would raise on the sun by its attraction would be tremendous. The effect might be

more like a waterspout than a tide, especially if the drawing force of the passing star were supplemented by the eruptive force of the sun, such as now throws up prominences.

Imagine such a tide, or spout, of the dense gases from the sun being drawn perpendicularly out of the sun in the direction of the passing star. As it rose thousands of miles above the sun's surface it would be given a sideward motion, also, in the direction in which the star was moving. It would tend to trail after the star. This sideward motion would be so rapid that when the visiting star had passed on too far to have very much more effect, even then the raised mass could not fall back into the sun, for its motion would give it sufficient centrifugal force to neutralize the attractive force of the sun.

Some of the material drawn off from the sun was probably given a velocity great enough to carry it on out into space never to return. Some, undoubtedly, was given too little speed to counteract the sun's attraction, and it would, after rising and going forward a certain distance, fall back on the sun at an angle, thus setting the sun in rotation in the direction of the passing star.

A large part of the raised mass, however, broke up into planets and continued to circle around the sun at varying distances out from it. It is probable that there was a good deal of scattered material at first, but this would be gradually swept up by the moving planets or would fall upon them as meteors now fall upon the earth. Perhaps these meteors are the last remains of this scattered material.

This is a brief statement of the theory which in its variously modified forms attempts to account for the observed facts relating to the solar system. The theory was first announced by Moulton and Chamberlain, an astronomer and a geologist, of the University of Chicago as early as 1900. It was originally known as the "planetesmal hypothesis," planetesmal meaning little planets, and referring to the supposition that much of the material was in scattered fragments which gradually collected around larger nuclei and grew into planets.

Naturally any conception of so vast an event happening some two billion or more years ago is subject to variations in its details as it is studied by other scientists, or even by the original propounders of the theory as they view it in the light of newly discovered facts. Jeans in his so-called "tidal" theory makes less of the probability that there was much scattering into frag-

ments, called planetesmals. The chief difference that this would make in the original conception is that the small fragments were supposed to cool and solidify quickly so that the earth and other planets would have been built up of solid particles, whereas Jeans' theory is that the large masses forming the planets passed from the gaseous stage into the liquid condition, and that then solidification gradually took place.

One proposal that the geophysicist Jeffreys and others have made is that there was actual encounter of the passing stars.

The planetesmal or tidal theory is at least as successful in explaining facts about the solar system as was the theory of Laplace, and, as already explained, it avoids the weaknesses of that hypothesis. The remarkable fact that the orbits of the planets lie so nearly in one plane is a natural deduction from such an origin. Likewise the plane of the sun's rotation on its axis is, as it should be, nearly in the plane of the planets. If the sun had a rotation before the planets were drawn off from it the direction of this rotation would probably have been nearly drowned out by the force of the falling material—the deluge of meteoric matter dropped from the loosened clutch of the visiting star's attraction as it receded into the distance. The equator of the sun is now only 7 degrees from the plane of the ecliptic.

As to the origin of the moon and other satellites two theories are pretty well balanced. One that they were made at the same time and in the same way that the planets were. The other that the orbits of the planets were at first very eccentric, allowing the planet once every revolution to pass close by the sun, in which case the sun might tear loose the satellites from the planets as *they* had been torn from the sun.

The most natural question that arises out of a consideration of the way in which we think the solar system originated is whether it is probable that there are other solar systems, other planets, other worlds like ours with, perhaps, inhabitants like ourselves.

If other stars were surrounded like the sun with a system of planets we could not see them since they would be so small, and would shine only by reflected light, and would be so close to the star as to be lost in its light.

Moreover it is not probable that very many of the stars have ever passed close enough to one another to draw off material for planets. The stars are so far apart and so relatively small

that according to computations that have been made the encounter or close approach of stars must be a very rare occurrence.

It is quite probable that the star which caused our system was affected much as the sun was by the encounter, since action and reaction are equal, and that it is somewhere out in the depth of space with its attendant planets. There may be many such systems, but in proportion to the total number of stars, those with a family of planets are supposed to constitute a small minority in the stellar universe.

CONCERNING I^n

By D. H. RICHERT
Bethel College, Newton, Kansas

In the November issue (1934) of SCHOOL SCIENCE AND MATHEMATICS, Professor L. R. Posey has developed a rule for finding the value and the sign of i^n. We propose another method which we believe to be more simple.

The short table for i^n where n takes the values 0, 1, 2, 3 is easily memorized:

$$(1)\qquad \begin{aligned} i^0 &= 1 \\ i^1 &= i \\ i^2 &= -1 \\ i^3 &= -i. \end{aligned}$$

The positive integer n can always be written in the form

$$(2)\qquad n = 4m + k.$$

where m is any one of the infinite set 0, 1, 2, . . . and k is one of the finite set 0, 1, 2, 3.

Now $i^{4m+k} = i^k$, which is one of the four values of (1).

Examples.—

$$(1)\qquad i^{13} = i^{(4)(3)+1} = i^1 = i$$

$$(2)\qquad i^{22} = i^{(4)(5)+2} = i^2 = -1$$

$$(3)\qquad i^{27} = i^{(4)(6)+3} = i^3 = -i$$

$$(4)\qquad i^{24} = i^{(4)(6)+0} = i^0 = 1.$$

We believe it is easier to memorize the four powers of i in (1) than to memorize the formulas on bottom of page 815 of the issue of this Monthly cited above.

SUGAR-OFF AND PLAY-DAY—HUDSON, OHIO

March 16, 1934

Science Teachers and their friends in all lines of work are asked to keep track of Captain Bill Vinal's announcement of the Sugar-off and Play-day for Nature enthusiasts at Western Reserve Academy, Hudson on Saturday, March 16, 1935, or thereabouts.

THE DAY WHEN SCIENCE WORK BECOMES PLAY!

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Twenty-Eighth Meeting

Boston University

668- Boylston Street, Boston. Room 22

Saturday, December 8, 1934

PROGRAM

9:45 Meeting of the Executive Committee.
10:00 Business Meeting.
10:15 Report of Committee on New Apparatus and other Committees.
10:45 Address of Welcome: Prof. Norton A. Kent, Boston University.
11:00 Address: "Airways Weather Service." Mr. A. D. Ross, Meteorologist at the East Boston Air Port.
11:45 Discussion: "The New Scheme of Grading C. E. E. B. Papers in Physics." Led by Mr. J. M. Arthur, St. Mark's School, Southboro, Mass. Mr. Arthur suggests that each member bring a copy of the paper.
12:15 Address: "Air Plane Superchargers." Illustrated. Dr. Sanford A. Moss, Thompson Research Laboratory, General Electric.

SPECIAL NOTICE

The yearly meeting of the New England Assciation of Colleges and Secondary Schools is to be held at the Hotel Statler in Boston on December 7. Our Association, together with several other similar groups, is cooperating with them and our members are invited to attend their meetings.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, WILLIAM E. SMITH, English High School, Boston, Mass.
Vice-President, JOSEPH M. ARTHUR, St. Mark's School, Southboro, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, PRESTON W. SMITH, Rivers School, Brookline, Mass.

BUSINESS MEETING

The following were elected to active membership:
Brian K. Connor, Barnstable High School, Hyannis, Mass.
John C. Gray, Phillips Academy, Andover, Mass.
Waldo H. Holcombe, Brooks School, North Andover, Mass.
L. R. Kirk, Gov. Dummer Academy, South Byfield, Mass.
Sebastian B. Littauer, Boston Trade School, Roxbury, Mass.
Robert P. Palson, Boston Trade School, Roxbury, Mass.

The President announced the appointment of committees for this year as follows:
New Apparatus: Robert W. Perry, Evans Webster, William M. Edmonstone.
Magazine Literature and New Books: Carl W. Staples, Kenneth L. Goding, Ralph B. Delano.
Current Events: John P. Brennan, Roger C. Chittendon, Enos E. Held.

College Entrance Requirements: Burton L. Cushing, Francis E. Mason, Frederick M. Boyce.
Membership: Lawrence A. Howard, Thomas A. Pickett, Joseph D. Danforth.
Publicity: Hollis Hatch.
Industrial Trips: Charles S. Lewis.

Upon motion of Mr. Cushing a vote of thanks was extended to Boston University and Prof. Kent for their hospitality in entertaining us at this meeting.

Prof. Norton A. Kent welcomed us in behalf of Boston University and added his own cordial personal greetings. He spoke entertainingly of some of his early experiences in Physics and called attention to an article in the April 1934 *Atlantic*, "Good bye, Mr. Chips." Prof. Kent left this thought with us, more important than method of teaching and knowledge of subject matter is "what the man really is."

REPORT OF NEW APPARATUS COMMITTEE

MR. ROBERT W. PERRY, *Chairman, Malden High School*

Mr. Hollis Hatch showed a new voltmeter. It has a two inch dial, D'Arsonval movement, and external zero adjustment. Full scale deflection needs five milliamperes so the 1000 ohm resistor, which makes it a 0–5 voltmeter, has been mounted externally where the boys can see it. Meters needing 1, 10, and 50 milliamperes are available at the same price or less. A similar instrument with three-inch dial is also available for 70 cents more. This meter is similar to several others on the market but costs the least of any having the above characteristics. The model cost $3.71 plus two binding posts and a piece of wood.

Mr. Carl Johnson exhibited several charts and told how they were used in studying parallel circuits, automobile wiring circuits, and Wheatstone bridge problems.

Mr. Winthrop Drury showed an easy way to cut tops from glass bottles and jugs.

From a dime-store get a 13-inch length of coiled resistance wire such as is used in electric grills or heaters, and an ordinary attachment plug-in cap such as plugs into wall sockets. The type of cap which has a shank to hold onto is preferable.

Now pull out about half an inch of each end of the coil, and fasten these ends firmly onto each of the prongs of the plug, forming thus a loop of resistance wire extending from one prong to the other. The wire should be threaded through the small holes in the prongs in such a way that it will pass over the outer ends. The prongs are then bent together to leave as small a gap as possible between the two sides of the heating loop, though of course they must not be permitted to touch.

After seeing that the bottle is cool, set it upright, and stretch the coiled loop over the top and down to the desired height, arranging it so that the gap avoids the joint where the halves

Resistance Coil arranged for removing tops from bottles

of the bottle come together. A laboratory stand and clamp is convenient for holding the plug in place. A 13-inch length of wire ought to make a good tight fit for bottles 5 inches and more in diameter; but if the coil has been stretched or bent in any way, make sure that it touches the glass all the way around, especially near the gap.

The 110-volt current is now turned on, and in less than a minute the glass will crack through by itself, and the top can be lifted off. The action is completely automatic, as the bottle does not have to be scratched or filed first, nor does it need to be rotated nor tapped while this short intense heating is going on.

During the process, it is advisable to hold the top in some way, or to insert a long stick in the bottle, so that if the top should happen to become dislodged after cracking loose it will not slide or fall off completely.

The sharp edges should be smoothed down with a triangular file or fine emery.

The elasticity of the coiled wire enables it to be used successfully on different-sized bottles: for example, gallon jugs 6½ inches across, and then smaller stock bottles of 5 inches. However, after the coil has been used a few times, it may become stretched so that it no longer makes a tight fit; and if it is too loose it may sag down when it becomes hot, and thus produce an irregular break. When such looseness occurs, it will be found a simple matter to work the coils together with the fingers, pushing on a small length at a time, and the loop will again be ready for business.

REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS

MR. C. W. STAPLES, *Chairman, Chelsea High School*

BOOKS

Modern Physics, by C. E. Dull. Henry Holt and Company, publishers

A new edition following the former edition rather closely, but including some new material, some changes in illustrations bringing them up-to-date and many new illustrations, with some changes in problems.

An Elementary Course in Photography. Prepared by Eastman Kodak Co., Rochester, N.Y.

A course intended for use, either as outlined, or in modified form, for science clubs, or in connection with other Physics work.

Foundations of Physics, by A. M. Butler. Barrows, publishers. $2.00 (see review below).

Electronic Structure and Properties of Matter, by C. H. B. Clark. Wiley, 1934. $5.00.

Vol. I, Comprehensive treatise of atomic and molecular structure.

Some Enigmas of Modern Science, by G. Clinton. The author, 124 Willow Ave., Takoma Park, Md., 1934. 8¢.

The Physical Basis of Things, by J. A. Eldridge. McGraw, N.Y., 1934. $3.75.

Dealing with relativity, the kinetic theory, quanta and optical spectra, x-rays, and the structure of the kernel, infra-red spectra, the nucleus, and the new physics.

The World in Modern Science, by Leopold Infeld. Putnum, 1934. $2.00.

The nature of scientific thought and method, as a basis of progress in physical science, the place of theory in process of scientific discovery and the part played by experiment, form a part of the plan of the book.

From Galileo to Cosmic Rays, by H. B. Leman. University of Chicago Press. $5.00.

Mystery Experiments and Problems for Science Classes and Science Clubs, by J. O. Frank and G. J. Barlow, J. O. Frank and Sons, publishers, 15 W. Irving St. Oshkosh, Wis., 1934. $2.25.

Technics and Civilization, by Lewis Mumford. Harcourt, Brace, and Co., N.Y.

The rise of technics and machines, their effect on civilization, and an attempt to understand the machine as a step toward reorienting our civilization, toward understanding society, and toward knowing ourselves.

Exploring the Upper Atmosphere, by Dorothy Fisk.

The Story of Energy, by Morton Mott-Smith.

A popularization of science; a history of the "quest for power" from ancient times, and a history of discoveries about energy down to recent developments.

Science for a New World. Planned and arranged by Sir J. Arthur Thompson. Edited by J. G. Crowther. "The Scientific Outlook on World Problems Explained by Leading Exponents of Modern Scientific Thought" (Sub-title).

Electric Meters, by R. R. Ranson Chicago, American Technical Society, 1934.

Electric meters, D. C. and A. C., measurements of power and resistance, reading and testing of watt-hour and graphic meters.

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Foundations of Physics. Reviewed by G. A. Cushman.

Alfred M. Butler, author, has very ably revised, improved and enlarged his Household Physics under the title of Foundations of Physics. There are three pages (roman numeral) prefatory matter and table of content; 602 pages (arabic numbered) of text material; 11 pages of index.

The general point of view of the book recommends it very strongly to me. I am convinced that by far the greatest value of our science work should be to inculcate the ability to think according to the scientific method. This cold logical recognition of facts and the drawing therefrom of unbiased generalizations is to be the salvation of our free society. Mr. Butler's book is based on this method throughout. His very first words in the preface: "the test of a person's education is his ability to make use of what he has learned—the training of the pupil to do his own thinking." This training is especially aided by the many common sense practical questions, simple, yet requiring independent thought. The questions occur throughout the book in quantitites, from 10 to 20 at the end of every little unit, and 40 or so at the end of chapters. For example, to illustrate their number, I counted 215 questions in the first 150 pages. There are also problems in limited numbers where they can be used to advantage. The value of these questions cannot be emphasized too much, for they are of the kind of which the new teacher has very few, for they depend upon the accumulation of teaching experience.

The book has an advantage, I think, in the absence of the confusing variety of type sizes and characters, found in recent books. The type is very clear, on good white paper; it is very easy to read. The careful explanations are complete and make the text material one that the youngster can understand. I believe it is better to have longer wordier explanations of few topics than many topics treated in so concentrated a manner that the pupil can readily understand nothing from the text alone. Again the method in this book. The language of the text is very happily free from scientific cant, is non-mathematical, and the explanations of the fundamentals are so definite and at the same time so simply worded that any student can understand them. The author has commenced by carefully apprising what the student's mental tool kit is likely to contain. The absence of the usual condensed summary at the end of chapters is an advantage, as it is in line with the idea of thinking, understanding rather than the mere cramming of facts.

The book is noteworthy for the large number of new illustrations—diagrams and pictures not usually found in texts. From turning over one-half the pages, I should say that not more than about a dozen times do there occur two consecutive pages of solid print unbroken by one or more illustrations. This visual education should help the book immensely.

The book begins with the subject of heat, which the author claims is the easiest to start with. This may be so; at least I know that the frequent opening subject of mechanics (machines) has not proved the easiest. The usual important topics are of course present, but more carefully selected. Features worthy of special mention are Household Plumbing and Automobile, topics not usually found but of very practical interest; also radio and talking movies, unusually complete and up to date; and lastly the very fine treatment of the topic of Optics.

In general this book meets every requirement of a general physics text, and might well be called the Physics of Everyday Life, because it touches practically every experience of the average person in a very clear and interesting manner.

Mr. Miller called attention to three books:

(1) *A Biography of Wallace Clement Sabine.* This is a book of unusual interest to all who knew Prof. Sabine and would be a source of inspiration to all physics teachers. The book is a fascinating story of the careful painstaking work which made Sabine the world's foremost expert in acoustics. His investigations into the cause of and the remedy for reverberations in theatres, churches and music halls are fully described. Privately printed by Plimpton Press. $5.00.

(2) *Romping Through Physics*, by Otto Willi Gail, Knopf. $1.50. A small book of 60 pages in which the essential facts in elementary physics are explained in a humorous way. Not a page without one or more comic diagrams. Although the book is very funny, it is not a joke. About two-thirds of any physics class would read it without urging. Just have it in sight on your desk.

(3) *From Galileo to Cosmic Rays*, by Lemon, Univ. of Chicago Press. This is a large book of the same type as Romping through Physics, but is written for more advanced students (college freshmen). The diagrams and pictures are very funny and well done. The artist has a gift. Fifteen copies of this book were recently bought by the Boston Public Library.

Mr. A. D. Ross, Meteorologist at the East Boston Airport, gave an exceedingly interesting talk on "Airways Weather Service." Although successful flying is so obviously very dependent on weather conditions it is surprising to the uninitiated to learn how complete a study is made of the air conditions and how promptly and thoroughly the results are made known to pilots.

Observations are regularly made at some 700 stations in the United States and these are sent by teletype to regional centers. Here the information is tabulated and interpreted and results radioed to planes every 30 minutes or so as occasion demands.

Such observations include temperature, humidity, wind direction and velocity at different levels, ceiling, visibility, etc. Besides the collection of these data at ground stations two other methods are used. From many stations small balloons carrying automatic recording instruments are sent up and in addition by observing their movements the direction and velocity of air currents is found. Also at the Boston airport and other major stations a plane with recording instruments and experienced observers is sent up to an altitude of 20,000 feet every morning to collect information.

Mr. Ross had for our inspection original teletype messages and explained the meaning of the various code symbols. He also brought samples of the various charts which are prepared, somewhat similar to weather charts.

The prediction of areas of sleet forming and foggy conditions is being quite successful although fogs on the coast of Maine do not seem to follow the general rules. Knowledge of these conditions along with wind velocities at different levels enables the pilot to change his altitude and fly at levels where the conditions are safest and most favorable.

Along a main airway as from Boston to New York a radio beam is in operation enabling a pilot to keep his course in foggy weather. So long as he is following the beam he hears a series of dashes but if he gets off his

course he hears on one side a dot-dash or on the other a dash-dot signal which tells him to which side he has gone.

The establishment of this meteorological service has rendered flying much safer for both pilots and passengers.

Mr. J. M. Arthur of St. Mark's School, Southboro, gave a brief discussion with charts and curves to illustrate how the College Entrance Examination Board had adopted a new scheme of grading in the attempt to smooth out the irregularities that have come from examinations of unequal difficulty. In each subject the same percentage of candidates are passed as have been passed, on the average, during the preceding ten years or more. The grades of the candidates were determined by a very careful adjustment of the curve of this year's results to that composite curve which showed the results of a long series of Board examinations in each subject.

An informal discussion followed in which many members participated.

AIRPLANE SUPERCHARGERS

By Dr. Sanford A. Moss

Thompson Research Laboratory, General Electric Co.

(Dr. Moss spoke informally illustrating his talk with many lantern slides. He also had for exhibition a collection of supercharger parts. He spoke of many interesting incidents and personal experiences which do not appear in the following abstract.)

The power developed by an airplane engine operating near sea level or at altitude can be considerably increased by the use of a compressor to force an additional amount of fuel mixture into the cylinders.

The cylinders of an unsupercharged engine operating at altitude are supplied with air at decreased density and the result is a decrease in the power developed. However, by means of a supercharger, the air pressure in the cylinders can be kept at sea-level value so that the engine continues to develop full power regardless of altitude. A supercharger arranged for this purpose can be used to increase the power at sea level within safe limits for the engine. This type of supercharger is driven either by gearing to the crankshaft or by a turbine operated by the hot exhaust gases of the engine.

Early in 1918, an exhaust-driven supercharger was installed on a Liberty engine. In order to test thoroughly the early apparatus, an expedition was arranged to the summit of Pike's Peak, where complete dynamometer tests, made at an altitude of 14,109 feet demonstrated the validity of the General Electric design. The armistice temporarily interrupted the development, but it was resumed shortly afterward, and a satisfactory type of supercharger, driven by exhaust gases from an airplane engine, was soon in production.

Improvements have been made from time to time, leading to the present design, which is in regular use by the U.S. Air Corps for high-altitude flying. The supercharger itself is an independent unit, consisting of a nozzle box, a turbine wheel, a centrifugal-compressor casing, and an impeller, the entire unit being bolted to the side of the plane.

The basis of the General Electric supercharger is the centrifugal compressor, which is, of course, similar to the well-known fan blower or centrifugal pump. However, in the case of the compressor, the speeds of impeller and fluid are vastly higher, and proper attention is paid to avoidance of loss of every kind.

The fluid enters the high-speed impeller near the center through an eye, or annulus, so proportioned as to give a proper compromise between too high a velocity of the fluid as it enters the impeller and too high a velocity of the blade tips which receive the fluid. These inlet tips of the impeller blades are bent forward so as to receive the fluid without shock. This is because at the inlet edges of the blades the fluid is proceeding at a certain angle relative to the blades. This relative direction is, of course, different from the absolute direction of the inlet fluid in space. The inlet edges of the blades must be exactly faced in the relative direction of the fluid. The impeller passage then curves so as to bend gently the direction of the fluid and pass it to the exit edges of the impeller blades, which are always in a radial direction. During the flow along the impeller from impeller entrance to impeller exit, the fluid has a certain relative velocity with respect to the impeller. The passage areas are so maintained as to keep this relative velocity comparatively small to minimize friction loss. At the impeller exit there is produced an appreciable pressure as a result of the so-called "centrifugal effect." The fluid, furthermore, has a high absolute velocity which is practically the velocity of the tips of the impeller blades. This velocity represents a certain amount of kinetic energy which has been imparted to the fluid, but which is not in useful form. This fluid is discharged at high velocity into a carefully designed passage beyond the impeller, called a "diffuser." The diffuser is so shaped as gradually to slow down the velocity of the fluid with the minimum of friction and eddy loss. Such an efficient decrease of velocity results in an increase of pressure, so that at the diffuser exit there is a pressure appreciably greater than at the impeller exit.

General Electric supercharges operate at from 15,000 to 30,000 r.p.m. The use of such speeds makes it imperative that all the passages, blade angles, and other items of mathematical design be carefully considered so that the high-speed flow may be handled without shock or loss. The supercharger impellers are made of heat-treated aluminum forgings.

Exhaust-driven superchargers are used for high altitude flying at 20,000 feet and upward. At 20,000 ft. altitude the atmospheric pressure is one-half, and at 35,000 ft. it is one-quarter, of the normal sea-level value. At such altitudes, the engine charge and hence the engine power are decreased proportionately. The object of the supercharger is to restore the engine charge and hence the power to the original sea-level value. The engine exhaust is completely enclosed in the manifold. When the engine is flying at altitude, there is maintained within this exhaust manifold the full sea-level pressure. The exhaust manifold leads the exhaust gases to a nozzle box which directs the exhaust gases on to the turbine wheel. The turbine is always located in the atmosphere without a casing of any kind. The gases pass from the nozzle box, wherein there is full sea-level pressure, to the high-altitude atmosphere at low pressure, resulting in a velocity which furnishes the power to drive the turbine wheel. On the same shaft as the turbine wheel, is the impeller of the centrifugal compressor, which serves to compress air from the low pressure at the high altitude to full sea-level pressure, at which it is delivered to the engine. Therefore, even though the plane is at high altitude, the engine exhausts at normal sea-level pressure and receives its charge at normal sea-level pressure, so that it necessarily delivers normal sea-level power.

For military, naval, and commercial work at sea-level and at moderate altitudes, geared superchargers are in extensive use.

The advantages gained by the use of a geared supercharger are improvement in vaporization, resulting from the passage of the mixture through the supercharger diffuser; increase of power, resulting from increased amount

of charge at sea-level (up to the maximum amount of power which the engine can develop safely); maintenance of full sea-level power at moderate altitudes, giving a remarkable increase in plane performance over that ordinarily obtained with impaired engine power at altitude; and emergency increase of engine power at sea-level during take-off, etc., beyond the amount safe for regular operation.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1354. *Charles W. Trigg, Los Angeles.*
1356. *J. B. King, Corsica, Pa.; J. E. Tuer, Orilla, Ontario.*
1357. *J. E. Tuer, Orilla, Ontario.*

SOLUTION OF PROBLEMS

1358. *Proposed by John Angel, Kemp, Texas.*

If a, b, c, are sides of a triangle, and t_a the bisector of angle A, prove

$$t_a^2 = bc - \frac{ba^2c}{(b+c)^2}.$$

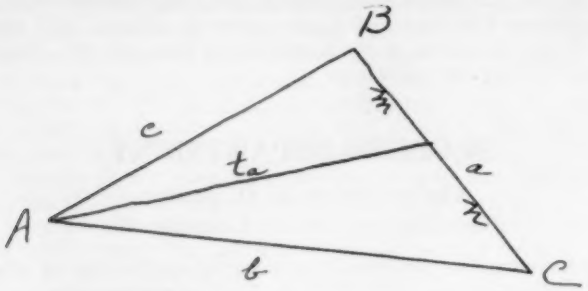
Solution by South Philadelphia H. S. Mathematics Club

1. $t_a^2 = bc - mn$

(The square of the bisector of an angle of a triangle is equal to the product of the sides forming the angle, diminished by the product of the segments formed by the bisector.)

2. $m:n = c:b$

(In any triangle, the bisector of an angle divides the opposite side into segments which are proportional to the other two sides.)



3. $m+n:n=c+b:b$, or
4. $a:n=c+b:b$, Hence
5. $n=\dfrac{ab}{b+c}$
6. $m+n:m=c+b:c$ (From 2). Then
7. $a:m=c+b:c$ Hence
8. $m=\dfrac{ac}{b+c}$
9. Substituting:

$$t_a^2=bc-\left(\frac{ab}{b+c}\right)\left(\frac{ac}{b+c}\right)$$

$$t_a^2=bc-\frac{ba^2c}{(b+c)^2}.$$

Solutions also offered by L. M. Bauer, Albuquerque; Charles W. Trigg, Los Angeles; W. E. Buker, Leetsdale, Pa.; Emanuel Gahan, M.D., New York City; J. O. Austin, Athens, Ill.; Maxwell and Mabel Reade; Norman Anning, University of Michigan; Herbert Sosensky, Brooklyn; Cecil B. Read, Wichita, Kansas; David Blackwell, Centralia, Ill.; Joseph L. Stearns, Washington, D. C.; Roy MacKay, Portales, N. Mex.

1359. *Proposed by Maxwell Reade, Brooklyn, N. Y.*

Bisect the angle formed by two non-intersecting, non parallel lines without prolonging the lines to their point of intersection.

Solution by Aaron Buchman, Buffalo, N. Y.

Given: Lines AB and CD, AB and CD intersect at an inaccessible point X.

Required: Bisect $\angle BXD$ without prolonging AB and CD to their point of intersection.

Let AB and CD intersect at the left. (The construction and proof are similar to the following when they intersect at the right.)

At any convenient point, E on CD, construct $EF \parallel AB$ and lying within $\angle BXD$

Construct EG, the bisector of $\angle CEF$

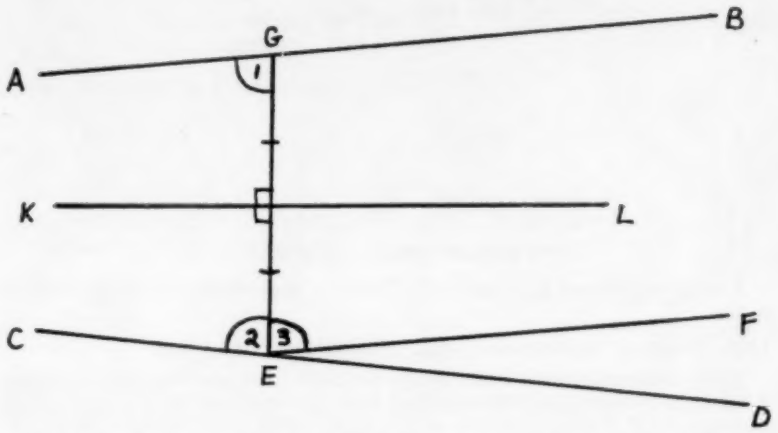
Let EG meet AB at G

Construct KL, the $\perp$ bisector of EG

KL is the required line.

Proof: It is easily shown that $\angle 1 = \angle 2$ so that $\triangle GXE$ is isosceles. The vertex of an isosceles triangle lies on the $\perp$ bisector of the base and the vertex angle is bisected by the $\perp$ bisector of the base

Then KL bisects $\angle BXD$.



Solutions also offered by Charles C. D'Amico, Albion, N. Y.; H. Grossman, N. Y. C.; Joseph L. Stearn, Washington, D. C.; A. V. Mantner, Channing, Mich.; J. O. Austin, Athens, Ill.; A. Struyk, Paterson, N. J.; W. E. Buker, Leetsdale, Pa.; Gordon Day, Waukesha, Wis.; Charles W. Trigg, Los Angeles; R. J. Strange, Omaha; Luther Ford, Grand Rapids, Minn.; J. B. King, Corsica, Pa.; L. M. Bauer, Albuquerque, N. Mex.; David Blackwell, Centralia, Ill. and the proposer.

1360. *Proposed by Maxwell Reade, Brooklyn.*

Find the sum to infinity:

$$\frac{3}{18}+\frac{3\cdot 7}{18\cdot 24}+\frac{3\cdot 7\cdot 11}{18\cdot 24\cdot 30}+\cdots.$$

Solution by Emanuel Gahan, M.D., New York City

For $|x|<1$, Gauss' hyper geometric series is convergent for all values of the parameters α, β, γ and the sum to infinity can be expressed as a definite integral.

$$F(\alpha,\beta,\gamma,x)=1+\frac{\alpha\beta}{1!\gamma}x+\frac{\alpha(\alpha+1)\beta(\beta+1)}{2!\gamma(\gamma+1)}x^2+\cdots$$

$$=\int_0^1 \frac{u^{\beta-1}(1-u)^{\gamma-\beta-1}(1-xu)^{-\alpha}du}{B(\beta,\gamma-\beta)}$$

where the denominator is the Beta Function. Now the given series $S=F(\frac{3}{4},1,3,\frac{2}{3})-1$; hence

$$S+1=1+\frac{\frac{3}{4}\cdot 1}{1!3}\cdot\frac{2}{3}+\frac{(\frac{3}{4})(\frac{3}{4}+1)(1\cdot 2)}{2!3\cdot 4}(\tfrac{2}{3})^2+\cdots.$$

Since

$$B(\beta,\gamma-\beta)=B(1,2)=\frac{\Gamma(1)\Gamma(2)}{\Gamma(3)}=\tfrac{1}{2},$$

we have

$$\tfrac{1}{6}(S+1)=\int_0^1(1-u)(1-\tfrac{2}{3}u)^{-3/4}du$$

$$=\frac{6}{S}\left[(1-\tfrac{2}{3}u)^{1/4}(1+u)\right]_0^1$$

$$=\frac{6}{5}\left[2\cdot(\tfrac{1}{3})^{1/4}-1\right]$$

$$S+1=\frac{12}{5}\left[2\cdot(\tfrac{1}{3})^{1/4}-1\right]$$

$$=\frac{1}{5}\left[24(\tfrac{1}{3})^{1/4}-17\right]$$

=a number between .2 and .25.

A solution offered by Charles C. D'Amico also offers $\frac{1}{4}$ as the sum of the series.

1361. *Proposed by Norman Anning, University of Michigan.*

If 6 cattle annihilate 4 acres of pasture in 25 days, and 8 cattle annihilate 5 acres in 20 days, find the smallest field that can not be stripped by 10 cattle.

It is assumed that the grass grows at the same rate, that the cattle eat at the same rate, and that the grass is uniformly distributed when the cattle are turned in.

Solution by Charles W. Trigg, Cumnock College, Los Angeles.

Let x = growth of grass in pounds per acre per day.
y = grass eaten by one cow in pounds per day.
k = pounds of grass per acre at start of grazing.
By the conditions of the problem,

$$4k+100x=150y$$
$$5k+100x=160y.$$

Solving,

$$x=\frac{11k}{100},\quad y=\frac{k}{10}.$$

Now if 10 cattle strip p acres in q days,

$$kp+\frac{11kpq}{100}=kq$$

i.e. $$p=\frac{100q}{11q+100}.$$

In the fraction which gives the value of p, it is seen that as q increases without limit p equals $\frac{100}{11}$. This means that 10 cattle could never strip $9^1/_{11}$ acres. However, 9 acres would last the 10 cattle 900 days.

Note. W. E. Buker, using the same equations, eliminates k and finds $y=^{10}/_{11}x$. His solution follows:

"Thus, one ox eats as much grass as grows on $^{10}/_{11}$ acres.

Ten cattle eat as much grass per unit time as grows on $9^1/_{11}$ acres in the same time.

So, any field containing less than $9^1/_{11}$ acres will eventually be stripped by 10 cattle."

Professor Anning announces the result as follows, "Ten immortal cattle can find eternal pasture on any field which contains more than $9^1/_{11}$ acres."

Solutions were also offered by Charles C. D'Amico, Albion, N. Y., and H. C. Torreyson, Chicago.

1362. *Proposed by Maxwell Reade, Brooklyn.*

Find

$$\int \frac{a \sin x + b \cos x}{c \sin x + d \cos x}\, dx$$

without using half angle substitution, when $c \neq 0$ and $d \neq 0$.

Solution by Jack Lorell, Mabel Reade, and the proposer.

Let

$$I = \frac{a \sin x + b \cos x}{c \sin x + d \cos x}\, dx.$$

By letting the numerator be identically equal to a constant, A, times the denominator plus a constant, B, times the derivative of the denominator, the integral is easily found. Thus,

Let $a \sin x + b \cos x = A\,(c \sin x + d \cos x) + B\,(c \cos x - d \sin x)$
$= \sin x(Ac - Bd) + \cos x(Ad + Bc)$ where A and B are to be determined by equating coefficients. Thus, from $a = Ac - Bd$ and $b = Ad + Bc$ we get

$$B = \frac{bc - ad}{c^2 + d^2} \qquad A = \frac{bd + ac}{c^2 + d^2}.$$

Hence,

$$I = \int \frac{bd + ac}{c^2 + d^2}\, dx + \int \frac{bc - ad}{c^2 + d^2} \cdot \frac{c \cos x - d \sin x}{c \sin x + d \cos x}\, dx$$

$$= \frac{bd + ac}{c^2 + d^2}\, x + \frac{bc - ad}{c^2 + d^2} \operatorname{Log} (c \sin x + d \cos x) + C.$$

A solution was also offered by Roy MacKay, Portales, N. Mex.

1363. *Proposed by William Kent and Emmett Durrum, Lewis and Clark High School, Spokane, Wash.*

A man arrives at a station $1\frac{1}{2}$ hours before the time at which he had ordered his carriage to meet him. He set out to walk at 4 miles an hour; he meets his carriage when it has traveled 8 miles, and reaches home one hour sooner than he had originally expected. How far did he live from the station, and at what rate was the carriage driven, assuming that it had left his home so as to reach the station at exactly the time ordered?

Solution by H. C. Torreyson, Chicago.

Let r = rate the carriage travels (mi./hr.) and d = distance the man lives from the station (mi.) Then

$$\frac{8}{r} \cdot 4 + 8 = d$$

and

$$\frac{2d}{r}-1=16/r.$$

Solving these equations for r and d we get $d=4$ and $r=-8$ or $d=12$, $r=8$.

The interpretation of the first set of answers is that the man lived 4 miles from the station, which distance he walked arriving at home $\frac{1}{2}$ hour before the carriage was scheduled to start to the station.

Also solved by W. E. Buker, Leetsdale, Pa.; Herman O. Masky, Fort Wayne, Ind.; David Blackwell, Centralia, Ill.; Aaron Buchman, Buffalo N.Y.; A. Struyk, Paterson, N. J.; Luther Ford, Grand Rapids H. S. Minn.; Chas. C. D'Amico, Albion, N. Y.; Emanuel Gahan, New York City; and the proposer.

Note: Two solutions assuming that the man walked $1\frac{1}{2}$ hours before meeting the carriage were offered. The man met the carriage at the end of 1 hour.—EDITOR.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1363. Agnes M. Higgins, Dunkirk H. S., N. Y.; Frederick B. Schelhorn, Abington (Pa.) H. S.

1359. Vitold L. Edutis and T. Tourog, both of Lane Technical H. S., Chicago; Virginia Esh and Jean Rynders of Dundes (Ill.) Community H. S.

1352. Adolph Trujillo, Menaul School, Albuquerque, New Mexico.

1358. South Philadelphia H. S. Mathematics Club.

PROBLEMS FOR SOLUTION

1376. *Proposed by Norman Anning, University of Michigan.*

Solve

$$\sqrt{x}-\sqrt{y}=-1$$
$$4\sqrt{x}=y.$$

1377. *Proposed by Maxwell Reade, Brooklyn.*

Find the indefinite integral,

$$\int\sqrt{1+\frac{\log x}{x}}\,dx.$$

1378. *Proposed by Charles W. Trigg.*

Prove geometrically that the medians of a tetrahedron meet in a common point which is three-fourths of the length of each median from its vertex. (A median of a tetrahedron is the line joining a vertex to the centroid of the opposite face.)

1379. *Proposed by William Kent, Spokane, Wash.*

Using only logarithms and doing no actual multiplication find how many digits there are in the integral part of the number represented by $9^{9^{9^9}}$.

1380. Evaluate

$$\sum_{0}^{\infty} \frac{(n+3)^2 x^{n+2}}{(n+2)!}.$$

1381. *Proposed by Norman Anning, University of Michigan.*

In a tetrahedron $ABCD$, $AB=CD$, $AC=BD$ and $AD=BC$. Prove that all four of the solid angles are equal.

SCIENCE QUESTIONS

February, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue
Cleveland, Ohio

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Wanted—Your mid-year examination papers. Thanks! Mail them.—Do it now.

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 50 others have already been admitted to membership by answering a question or proposing one that is published.

Answers are lacking to Questions 669, 670, 671, 672, 673. Submit them to your classes; send in the answers.

BECOME MEMBERS OF THE GQRA

AN ANSWER—A QUESTION—A DISAGREEMENT

Physics Classes of Riverside High School, Buffalo, N.Y.
(Elected to GQRA No. 50, for submitting the discussion which follows)
Kazimeria Koczot, Riverside High School, Buffalo, N.Y.
(Elected to GQRA No. 51, for submitting Question No. 683)
Louis T. Masson, chairman, Science Department, Riverside H. S. Buffalo, N.Y.
(Elected to GQRA No. 52 by reason of the following)

EDITOR, SCIENCE QUESTIONS. Buffalo, N.Y. Dec. 20, 1934

We have been interested in your recently formed GQRA and have followed your questions and answers eagerly. The physics classes of Riverside High School would like to become members of this organization and in accordance we are doing two things: (1) submitting a question as required; (2) commenting on an answer to a question appearing in the December issue of your publication.

683. *The question is proposed by Kazimeria Koczot and it asks:*

"How cold is *twice as cold as zero*, (using 0 deg. C. and 0 deg. F. as two separate problems)? Similarly, how cold would *three times as cold as zero* be?"

656. *The comment on the answer to Problem 656 in the December issue is as follows:*

A body will weigh more in a vacuum than in air, and *NOT the same* as contended by two students of the Rizal High School, P.I. There is a simple demonstration to prove that the weight of air displaced by even small bodies buoys them up and makes them lighter. The device is listed in any apparatus catalog as a baroscope and consists of a simple equal-arm balance with a 7.5 cm sealed *hollow* globe on one end and a *solid* counterbalancing weight on the other end. In air, they balance perfectly; when placed under the receiver of an air pump and the air exhausted, the balance is disturbed, the spherical ball appearing to be heavier because there is now no buoyant effect of the air. The solid weight has also lost in buoyancy but since its *volume* is smaller than that of the hollow ball, its loss in "support" is less than that sustained by the ball. When air is re-admitted to the receiver, the equilibrium is slowly restored.

As a further line of reasoning in this connection think of a toy balloon containing hydrogen, with a string and small weight so adjusted that the balloon neither rises nor falls in air,—in other words the balloon and its parts weigh exactly as much as the displaced air. Such a balloon suspended from a sensitive spring balance would register a weight of zero. Now imagine the air removed or evacuated and two questions arise (1) would the balloon still remain motionless in space as in the hypothesis when the air is removed and (2) if suspended from the balance, would the balance still register zero?

We must not lose sight of the fact that all bodies surrounded by air are really *immersed* in air and subject to the Principle of Archimedes for all fluids. This is an important practical consideration in the recent sending of balloons into the stratosphere. If bodies weighed the same in a vacuum as in air, what would prevent such a balloon from rising indefinitely? It is the fact that a rising balloon passes through all possible shades of an atmosphere that is gradually becoming "vacuumized." When the weight of the displaced air is no longer able to exceed the weight of balloon and contents, further elevation becomes impossible and horizontal motion only can take place. This simple discussion, of course, disregards leakage of gas from balloon, convection currents in stratosphere, etc.

If the above line of reasoning is incorrect, our class would like to be informed.

Thank you for your consideration of the above.

SOME NEW THOUGHT-PROVOKERS

Proposed by Rawlins S. Coke, Steuben Junior High School, Milwaukee, Wis.

This evening I have spent about three hours reviewing all magazines back to February 1929 to catalogue all general science tests printed. The related material has proved quite interesting also. Despite my subscriptions to this magazine, this is the first time I have read through your articles thoroughly.

Are you still asking for "Thought-Provokers"? Maybe the following have not been sent to you as yet:

684. *Question:* When an irresistible force strikes an immovable object, what will happen?

685. *Question:* Two boys stand together out in the middle of a lake on the surface of level ice with ice skates attached to their shoes. Suppose that the movement of the skates on the ice is frictionless, without taking off their skates or calling for any external help, how are they to get to shore?

RESULTS ON STRAUSS'S BIOLOGY TEST

679. *Proposed by Samuel Strauss (GQRA No. 21), Garfield High School, Akron, Ohio. (Published in November, 1934.)*

Answers by Classes of George R. Biecher, Chambersburg, Pa. (Elected to GQRA, No. 54.)

The test was mimeographed and given to all of my classes which totaled 201 pupils: These pupils having completed the study of "Foods" as a unit of instruction the day before presentation of the test. The unit of instruction was prepared by myself and based on the preparation of a "Scrap Book," which I should like to publish in SCHOOL SCIENCE AND MATHEMATICS in the near future.

However, I should like to know the interpretation of the test results according to Mr. Strauss before publication of my unit. Therefore, I am enclosing a self-addressed envelope, looking for a reply at your earliest convenience.

The results are as follows:	The numbers given marked "X".
Part I.	Part II. (Reasons)
1. 44	1. 84
2. 186	2. 165
3. 152	3. 188
4. 80	4. 148
5. 172	5. 168
6. 133	6. 2
7. 33	7. 194
8. 78	8. 190
9. 181	9. 37
10. 85	10. 187

Some of the pupils thought he might obtain this fish at Little America.

Answers by Classes of Rawlins S Coke, (GQRA. No. 53) Steuben Junior High School, Milwaukee, Wis.

Out of 80 students in two classes about 60 are "Y's" (average): 10 are "X's" (superior), and about 10 are "Z's" (low) as determined by intelligence tests.

Answers	Reasons
1. 22	1. 25
2. 73	2. 73
3. 72	3. 76
4. 33	4. 59
5. 79	5. 72
6. 59	6. 3
7. 15	7. 74
8. 25	8. 68
9. 75	9. 6
10. 42	10. 72

My Science (General) Classes were tested one month after a one-week's study of "Foods." The number given opposite the number of the question shows how many marked "X" in the respective parentheses.

HEAVY WATER FOR SALE

686. *From an advertisement on page x, April 1934, "The Review of Scientific Instruments."*

A manufacturer of chemicals says:

"We have available for immediate shipment, a quantity of this new and interesting material (deuterium oxide) in the following concentrations: .05 mol per cent; .10 mol per cent; .47 mol per cent; also 95% or better."

(1) What is deuterium oxide?

(2) What does the expression ".05 mol per cent" mean?

(3) What interesting experiments have been performed with "heavy water"?

A PUZZLER FOR THE THINKERS

Proposed by W. E. Buker, (GQRA. No. 22), Principal High School, Leetsdale Borough Schools, Leetsdale, Pa.

Here is a puzzle that is going the rounds. I don't know just who the originator was, but it's not so bad, and I thought some of the readers of SCHOOL SCIENCE AND MATHEMATICS who do not know it might like to try it. Here it is.

686. A king blindfolded three of his subjects and touched each on the forehead. They knew that the finger touching them might or might not be covered with lampblack. When the blindfolds were removed, they were given instructions to start whistling if they saw one or more black spots. As soon as any one of them could figure out whether he himself had lampblack on his forehead, he was to stop whistling.

There were spots on all three foreheads, and presently A stopped whistling. How did he know he had lampblack on his forehead?

(Teachers are asked to try this out on three pupils in some class, find out whether the pupils can figure it out. Put lampblack on all three foreheads. Report your results.—Ed. Jones).

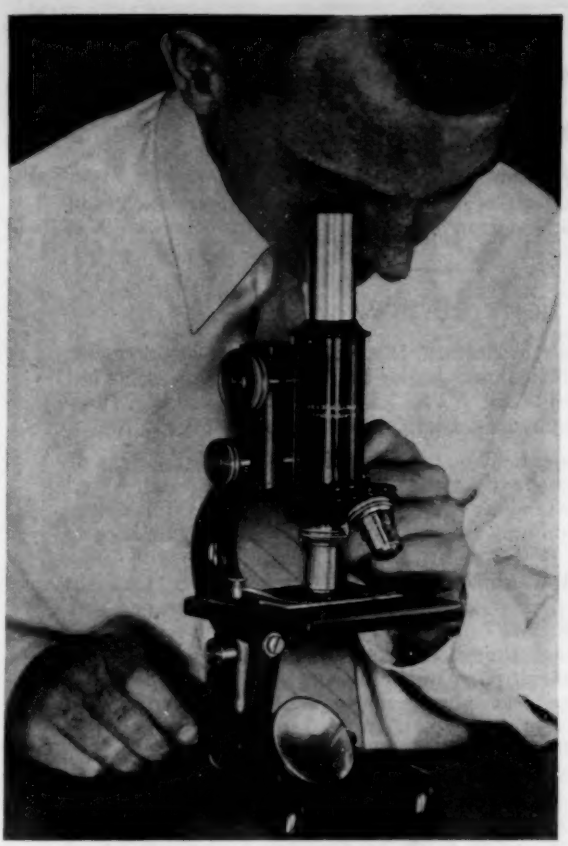
GENERAL SCIENCE QUESTION

687. *Proposed by Arnold Bookheim, (GQRA, No. 36), Williamson, N.Y.*

Write after each word or statement below, the word or statement from the following group that best matches it: weather factor, iodine, anticyclone, prevents rickets, Fehling's solution, oxygen, vitamins, carbon dioxide, nutrient, nitric acid, part of eye, cyclone, precipitation, measure of heat. (A word from this group may be used more than once.)

1. optic nerve .....
2. a low .....
3. used in protein test .....
4. fat .....
5. calorie .....
6. turns limewater milky .....
7. snow .....
8. sugar .....
9. low pressure area .....
10. retina .....
11. air temperature .....
12. crystalline lense .....
13. dew .....
14. prevent deficiency diseases .....
15. used in test for starch .....
16. brings rainy weather .....
17. air pressure .....
18. carbohydrates .....
19. glowing splinter bursts into flame .....
20. a high .....
21. turns red when sugar is present .....
22. air motion .....
23. frost .....
24. mineral .....
25. brings fair weather .....
26. protein .....
27. rain .....
28. humidity .....
29. high pressure area .....
30. vitamin D .....

(Try it out with *any* class. Please report results to Ed. Jones.)



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FOR THE CHEMISTS

688. *Proposed by Maxwell Reade (GQRA, No. 48), Brooklyn, New York.*
In a solution containing 50 mg. Pb^{++} and 3 mg. $Ag.^{+}$ which will precipitate out if NaCl is added drop by drop?

BOOK REVIEWS

Units in Chemistry by Russel S. Howard, Head of the Science Department, Lyons Township High School and Junior College, La Grange, Ill. First Edition, pp. viii+356+lxviii. 3.2×14.5×20.4 cm. Profusely Illustrated. (356 figures and pictures) Cloth. 1934. Henry Holt & Co.

Here is something different. The author sensibly says "New Texts do not usually bring forth any great volume of new scientific material. About the only excuse (for them) is that they may contribute something new in the manner of organization and methods for increasing the efficiency of presentation."

As the title suggests, the subject is studied in units. There are eight principal units. Each of these "is a center about which is grouped contributing knowledge in order to bring about a well defined understanding of chemical principles. Each unit is devised to stand upon those which precede it." The more difficult parts of the subject are deferred until late in the course so that the pupils are not given too much to attempt at first and their abilities are given plenty to attempt when they have grown in power with the advance of the course.

A casual study of the method of the text suggests that one might go yet further in the matter of subdividing the course into units, devising more and simpler ones. A vast amount of material is provided, even in the first unit. This further subdivision can easily be done by any teacher who is using the book.

A very complete elementary treatment of organic chemistry is given in the last unit and this is justified by the author on the ground that the pupil is likely to encounter about as much organic chemistry in his daily life as inorganic.

Teachers of chemistry in secondary schools will want to examine this new text with its original treatment of the subject.

F. B. WADE.

The Diffraction of Light, X-Rays and Material Particles, by Charles F. Meyer, Associate Professor of Physics, University of Michigan. Cloth. Pages xiv+473. 16.5×24 cm. 1934. The University of Chicago Press, 5750 Ellis Ave., Chicago, Ill. Price $5.00.

Beginning with the discovery of diffraction by Grimaldi this book gives a comprehensive treatment of the development to the present time. Here is brought together in one volume much information otherwise available only in scientific journals and reports both American and foreign. Full references are given and the methods and results are critically examined. The language is as simple and direct as can be used in treating a subject of this type. Interspersed are human interest sketches of the lives of Young, Fresnel, Fraunhofer and other pioneers in the field.

The early chapters discuss the Fresnel and Fraunhofer diffraction cases. First the zone method is explained; this is followed by the method of lunes and the geometry of the Cornu spiral. Typical diffraction patterns are diagrammed and the theory applied. Directions are given for producing

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diffraction patterns, photographing and measuring them, and comparing results with theory by applying the Cornu spiral. A section of 180 pages is used in the discussion of the diffraction grating. The theory, types of gratings, methods of ruling, mountings, and errors of ruling are amply treated. Chapter VII correlates theory and practical application. Experiments are suggested to verify theory. Some of the topics discussed in detail are resolving power of telescopes, gratings, prisms and microscopes, measurement of star diameters, measurement of diameters of microscopic particles, scattering of light, and meteorological phenomena.

The eighth chapter, eighty-four pages in length, gives the story of X-rays. Beginning with their discovery by Roentgen in 1895 the author gives a brief survey of their nature, the methods of investigation and measurement, and the theory developed. The contributions of Laue, the Braggs, Moseley, Compton, Allison and others are described. Particular attention is given to crystal diffraction patterns and their interpretation, and to the use of the double crystal spectrometer.

The last chapter discusses the interesting discoveries of very recent years beginning with the experiment of Davisson and Germer for diffracting electrons from the surface of a nickel crystal. A summary of De Broglie's wave theory of matter, Thomson's method of diffracting fast electrons, Kikuchi's patterns from very thin films, scattering by fluid streams, and the experiments on larger particles by Stern, Demster and others brings the story to the present year.

The book is a valuable contribution in this field and is suitable for both text and reference work in college and university classes.

G. W. W.

Spiel und Spielzeug im Physikunterricht (Games and Toys in the Teaching of Physics) by Dr. G. Dussler, *Studienassessor* in Ettal. Paper. Pp. 79. 20×27 cm. One etching, 169 figure drawings, three art halftones. *Beihefte der Unterrichtsblätter für Mathematik und Naturwissenschaften*, No. 13. Otto Saale, Frankfurt A.M., 1932.

The author adapts materials from his dissertation on this problem. He suggests games and toys to aid in the problem of student interest and psychological effectiveness in the teaching of physics to children. His introduction reviews the history of the problem and his bibliography lists 95 references, mainly to German writers, dealing with this problem, also as applied to mathematics. In Part I he proceeds on the principle that the laws of physics, inductively presented by games and toys, contact more readily the apperceptive mass, fringing past experiences and present experiments into closer correlation, converting more smoothly the naïve, pre-science and pre-physics thinking of the child into habits of observation and scientific thinking. He points out that most of the adult's physico-technical experience is represented in toys, as these miniatures present the principles of the more common inventions. He discusses the adaptation of materials to age, previous experience and sexes; suggests pertinent mathematical and thought problems and motivation to home experimentation of laws learned. Part II consists of practical examples of how games and toys may be used.

The 169 drawings are well done and include an abundant array of simple toys illustrating the laws of physics usually taught. The games listed are about as typical as "tug-of-war," "whip-cracking," "tag," etc. The author concludes with a recommendation of an introductory course of physics in the *Volksschule*, conducted along the lines suggested by him. The book has a good index.

A. H. THOMAS

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Silver Jubilee Commemoration Volume. Indian Mathematical Society. Journal Vol. XX. Cloth. Pages x+248. 16×24.5 cm. 1933.

This volume is issued in commemoration of the founding in 1907 at Madras the "Analytical Club" which is now the Indian Mathematical Society. In it we find a report of the Eighth Conference and Silver Jubilee Celebration of the Indian Mathematical Society and twenty-two papers dealing with research problems in mathematics.

Among the contributors are two Americans—Professors G. A. Miller and E. T. Bell.

J. M. KINNEY

The Poetry of Mathematics and Other Essays, by David Eugene Smith, Professor Emeritus of Mathematics, Teachers College, Columbia University. Cloth. Pages v+91. 13×19 cm. 1934. Scripta Mathematica, Yeshiva College, New York City. Price: Paper cover, 50 cents; cloth, 75 cents.

This book is a compilation of five articles by Professor Smith which have appeared previously in the American Mathematical Monthly, Scripta Mathematica, and the Mathematics Teacher. Their titles are as follows: The Poetry of Mathematics, The Call of Mathematics, Religio Mathematici, Thomas Jefferson and Mathematics, and Gaspar Monge, Politician.

In the first article the author points out a number of similar characteristics of mathematics and poetry. They deal with truth and with the infinite. They express thought in concise form. They express thought in beautiful forms. They require imagination on the part of their inventors and there is no end to their inventions. In the second article he discusses the utility of mathematics, not only as to its applications in science and industry, but also as to its cultural value. In Religio Mathematici he points out the duality of mathematics and religion. The article on Thomas Jefferson shows that Jefferson was interested in mathematics and did much to encourage the development of mathematics in this country. The article on Gaspard Monge is based on unpublished documents, now in the library of Columbia University, relating to Monge and his family. It presents Monge, the great mathematician, as a man of affairs during the turbulent period of the French Revolution.

This little volume should be read by all teachers of mathematics and those who are interested in science and mathematics.

J. M. KINNEY

Essentials of Plane Trigonometry, by Atherton H. Sprague, Associate Professor of Mathematics, Amherst College. viii+124 pp. Prentice-Hall, Inc. 1934. Price $.80.

The title of this text is descriptive of its contents. Professor Sprague has selected the essentials of plane trigonometry and organized them into a unified whole. The functions of acute angles and the solution of the right triangle are introduced before the generalized functions and the solution of the oblique triangle are discussed.

A great number of exercises are found under each topic. The author has included a supplementary chapter which the more ambitious teacher will find useful. The usual tables found in a trigonometry book are included in this text.

G. L. ROYCE

Solid Geometry by Frank M. Morgan, Director of Clark School (College Preparatory), Hanover, N.H.; formerly Assistant Professor of Mathe-

matics, Dartmouth College, Hanover, N.H. and W. E. Breckenridge, Head of the Department of Mathematics, Stuyvesant High School, N.Y.C. vii+722+viii pp., Houghton Mifflin Co., 1934. Price $1.24.

The reviewer sincerely feels that the authors of this textbook have made a real contribution to the teaching of solid geometry. He feels that there will be few adverse and many complimentary criticisms of this text.

The text contains a wealth of exercises on each topic, a very desirable thing in any text, and among these will be found many drawing exercises. The authors have also included completion and true-false tests. On the whole the diagrams are well drawn, although some of those in the section on spheres could have been improved. The reviewer wishes to take exception to the diagram for the theorem *two planes perpendicular to the same line are parallel*. He feels that it is in no way justifiable as it does not fit the facts of the theorem. The reviewer also feels that it would have been a sounder educational procedure to have stated the theorem used in proofs instead of refering to them by paragraph numbers.

Although this book is a sequal to "Plane Geometry" by the same authors it can be used independently of it. The publishers deserve credit for using a large clear type throughout the book.

G. L. ROYCE

Trees of North America (Exclusive of Mexico), by George Rex Green, Professor of Nature Education, The Pennsylvania State College. Volume II, The Broadleaves, Cloth. Pages xvii+344. 21×27 cm. 1934. Edwards Brothers, Inc., Ann Arbor, Michigan. Price $3.50.

The first volume of this series covered the Conifers. This volume there-

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Adventures in Biology, by Julius Schwartz, Louis Eisman, Maurice Kurzman, Susan Lieberman and Mildred Schnur, teachers of Biology in the High Schools of the City of New York. Bound in cardboard, 59 pages, size 12 mo. Published by the New York Association of Biology Teachers. Headquarters, Grover Cleveland High School, Brooklyn, New York. Price 50 cents. 1934.

Teachers of biology will be delighted with this booklet. It is evidently the result of years of careful work by progressive teachers. The title, "Adventures in Biology" really expresses the truth about the book, but is not particularly enlightening. To be more explicit it is a book of suggested projects for students of biology, each of which may be thought of as an adventure for the enthusiastic student.

There are 286 of these suggested projects, arranged in groups according to their nature. The following are some of the topics under which the projects are arranged: Group I "Our plant and animal environment," 64 projects. II "Nutrition," 34 projects. III "Growth and Development," 29 projects. There are ten of these groups of projects in all, covering the field of biology. Each project has brief suggestions for starting the work, and references to a bibliography, which contains a list of authors and titles from which further help may be obtained. There are 680 references in this bibliography. Thus, it will be seen that the booklet has received much careful study, and is a testimonial of the highest character to the quality of the teaching being done by the biology teachers of New York. It will be a boon to any biology teacher who wishes to gain the enthusiastic interest of his pupils in the study of biology.

W. WHITNEY

Introduction to Practical Astronomy, by Dinsmore Alter, Professor of Astronomy, University of Kansas. Cloth. Pages viii+80, also 16 pages polar coördinate paper and 32 pages rectangular coördinate paper. 18×25 cm. 1933. Thomas Y. Crowell Co., New York. Price $2.00.

This is a manual for the study of astronomy. It consists of twenty-nine exercises and experiments with a brief discussion of the basic theory, covering such topics as the astronomical systems of coordinates, transformations from one system to another, some of the effects of precession, observations with an engineer's transit and with an equitorial telescope. Students of elementary astronomy will find it an excellent help.

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SIXTEENTH ANNUAL MEETING OF N.C.S.E.S.
FEBRUARY 23, 1935

Hotel Chelsea, Atlantic City, N.J.

FORENOON MEETING 9:30–11:45

9:30 *The Rooms, Service, Furnishings, and Equipment Used in the Teaching of Elementary Science in the Grades*—H. A. Cunningham, Kent State College, Kent, Ohio.

10:00 *Elementary Science with the Classroom Teacher*—Agnes W. Nemir, Supervisor of Elementary Science, Glens Falls, New York.

10:20 *The Development of a Program in Science and Health for the Kepner Elementary School*—Rose Lammel, Colorado State College, Greeley, Colorado.

10:40 *The Use of Live Animals in Elementary Science Work*—Morris B. Shoemaker, North Arlington, New Jersey. Formerly at the State Museum, Trenton. (Mr. Shoemaker will bring the live animals with him for demonstration.)

11:10 *Finding and Using the Natural Resources of the Community*—Marcia A. Everett, Department of Public Instruction, Belvidere, New Jersey.

11:30 *Discussion*

12:15 *Luncheon Meeting.*
Guest speaker, Professor C. B. Bazzoni, University of Pennsylvania.
Messages to Elementary Science Teachers—from Albert Einstein, Henry Fairfield Osborn, and Harlow Shapley.

AFTERNOON MEETING

2:15 *The Integration of Science and Social Studies in the Elementary Schools*—Rose Wyler, State Normal School, Plattsburg, New York.

2:40 *The Integration of Pure Science and Social Science at the High School Level*—David E. Harrower, Woodmere Academy, Woodmere, New York.

3:05 *Science Activities in the Elementary Schools of Nutley, New Jersey*—Margie Phillips, Washington School, Nutley, New Jersey.

3:30 *Discussion*

3:45 *Business Meeting for Members Only*

MONDAY AFTERNOON, FEBRUARY 25

2:30 P.M.—Joint meeting with the *Department of Supervisors and Directors of Instruction.* Auditorium. Committee Room 2.

Problems in the Supervision of Elementary School Science

Presiding—Edward E. Wildman, Director of Science Education, Philadelphia, Pennsylvania.

The Place of Science in the Elementary School Program—Mrs. Dessalee Ryan Dudley, Assistant Superintendent, Battle Creek, Michigan.

The Organization of the Course in Science for Elementary Schools—Gerald S. Craig, Teachers College, Columbia University.

The Question of Science Equipment and Materials—Harry A. Carpenter, Specialist in Science, Rochester, New York.

The Training of Teachers of Science in Elementary Schools—Charles J. Pieper, New York University, New York.

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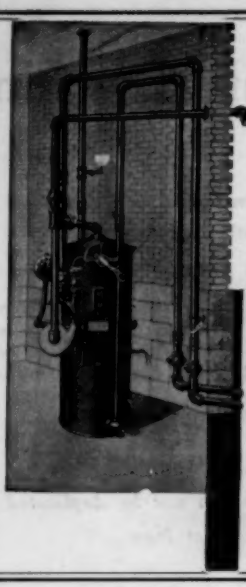

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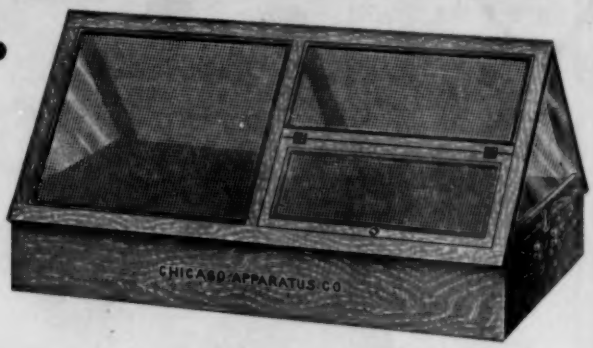

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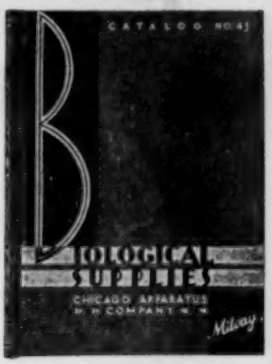

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